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Equipment Sharing and Cost Estimating for Rural Solid Waste Disposal Systems

A. W. Martin Associates, Inc, King of Prussia, Pa

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EQUIPMENT SHARING AND COST ESTIMATING FOR RURAL SOLID WASTE DISPOSAL SYSTEMS

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SECTION 1

SUMMARY AND CONCLUSIONS

The present study is an analysis of six rural county solid waste disposal systems located in the western and southern U.S. The landfill sites studied vary considerably in locale, climate, population, volume of solid waste generated, systems of disposal, and disposal costs. The solid waste disposal systems encountered in this study include one landfill equipment-sharing system, a bulk container collection/transfer station system, a system of one main landfill and smaller satellite landfills, and combination of these practices. Very few of the landfills maintain daily records of logs identifying quantities of waste processed, total labor costs, equipment owning costs, and equipment operating costs. None of the small (satellite) landfill sites investigated meet EPA sanitary landfill requirements for daily cover.

The potential of landfill equipment-sharing systems for rural areas, in which equipment is hauled from site to site as needed to perform required landfill functions, is significant in that equipment and manpower are more fully utilized and capital is not tied up in machinery that receives only occasional use. However, for such a system to be economically feasible, travel time must be minimized and operations must be staggered to avoid overextension of the system. In the Graham County case, the operator's time is divided 20-80 between equipment transport and landfill operations, which means that 20 percent of the operating time is spent in loading, traveling, and unloading.

The results of this study indicate that the bulk container transfer system is also a viable solid waste management alternative for rural areas, especially when landfill sites are not readily available. The transfer station system requires that container stations be readily accessible to transport vehicles and that suitable containers and transport equipment be carefully selected. Savings on the purchase of containers and hauling equipment are generally offset by increased operating expenditures. Before a bulk collection system is implemented, the quantity of solid waste generated in each district to be served must be determined so that reasonable pick-up schedules and routes can be established. Such information must be evaluated in terms of the economic objective of collection frequency--shortest routes and optimum loads.

In the initial development of any solid waste disposal system for rural areas, the most important factors to be considered are as follows:

1. Availability of suitable disposal sites.

The landfill site must be carefully selected on the basis of existing zoning regulations, the geology of the area, the nature and availability of cover material, the land area available for disposal, the depth available for filling, and the anticipated life of the landfill. The transfer station site must be selected on the basis of zoning, accessibility, surrounding highway network, and its compatibility with the land use of adjacent properties.

2. Highway network serving the region.

The selected sites should be easily accessible to all vehicles. The roads should be adequate in width, and the pavement structure should be of sufficient design and construction to support loaded transport vehicles. The access routes to each landfill site should be identified during the site selection and, ideally, an alternate route should be investigated as a safety precaution.

3. Location of solid waste generators with respect to disposal sites.

In order to encourage low-volume generators to use the disposal facilities, travel distances should be reasonable. If residents bring their waste to the disposal sites rather than dump on the roadside, the county will be relieved of the responsibility of collecting it. If the distance to the disposal facilities is too great, rural residents may be inclined to use unsuitable alternative disposal methods.

4. Initial costs of equipment.

The type, size, and quantity of equipment to be purchased will be a function of the method of landfilling selected, the volumes of waste to be processed, the operating personnel available, and the conditions at the disposal site. Equipment costs are of primary importance and should not be overlooked during the initial disposal system development. Undersized, oversized, or otherwise inappropriate equipment for the operations to be performed will result in additional expense and operating cost. Savings on low initial costs for equipment are usually lost in high operating costs.

5. Manpower requirements.

Considerations to be made in estimating manpower requirements are: the number of disposal sites, the volumes of refuse to be handled, the type of disposal operation to be practiced, the amount and type of equipment to be operated, the size of the area to be served, the experience of the operators, and the part- or full-time basis of operation.

6. Schedule of operations.

The development of a schedule of operations is an important part of disposal system planning. Such a schedule must be both reasonable in its demands on manpower and equipment and flexible in its execution. Planning for a schedule of operations should consider seasonal variations in both solid waste volumes and climatic conditions. Where equipment must be transported, consideration must be given to equipment utilization; a minimum time should be allotted to transportation and a maximum to the landfilling operations as much as possible. Experience indicates that the development of a schedule usually involves as much trial and error as initial planning and calculation.

7. Effective cost-accounting methods.

The two major costs of operating a solid waste disposal system are equipment and labor. The total cost of disposal varies depending on the volumes of waste handled and the methods and efficiency of the operation. An accounting system should be used to keep an ongoing record of all expenses associated with any solid waste disposal operation. Control can only be exercised over a system in which operating costs can be identified and adjusted. Such a system will be useful in the planning and design of the continuing disposal system. The U.S. Environmental Protection Agency has

published two very helpful pamphlets on sanitary landfill accounting systems which are recommended for use by solid waste disposal operations (see Zausner 1969, 1970).

Through a strategic approach based on these seven initial considerations, and an informed evaluation of available options, rural municipalities should be able to develop a solid waste collection and disposal system suited to their particular needs.

On the basis of these six case studies it is concluded that:

1. There are several viable options for solid waste management in rural counties:

   a. an equipment-sharing system with staggered hours of operation for the landfill site.

   b. an equipment-sharing system with staggered hours of operation and attendant transfer stations.

   c. a transfer station system with either one or two landfills, each having its own equipment and each open for disposal on a scheduled day, with on-site provisions for disposal during off-hours (collection boxes).

2. Oversized equipment is more efficient in landfill and transport operations than undersized equipment.

3. A system can be developed in which equipment is shared between two or more landfill sites; however, it requires staggered hours of operation, reasonable haul distances, and provisions such as collection boxes stationed at the landfills for disposal when the gates are locked.

4. There is a need for preventive maintenance programs for equipment used in rural solid waste disposal systems.

5. There is a widespread need for record-keeping of costs, operation, and equipment utilization in rural solid waste disposal systems.

6. The findings of this study suggest that additional case studies of diversified rural solid waste disposal systems should be undertaken in the near future for the purpose of documenting the capabilities of little known but workable systems and establishing additional cost and efficiency data for use in upgrading existing operations and in developing new systems.

SECTION 2

INTRODUCTION

The purpose of this study was to evaluate rural landfill systems and to develop a descriptive cost-estimating tool to be used by other communities in evaluating the applicability of these systems to their particular needs. Six counties were selected for investigation in concurrence with the U.S. Environmental Protection Agency; they are: Graham County, Arizona; Habersham County, Georgia; Cascade County, Montana; Lake County, Florida; Leon County, Florida; and Catron County, New Mexico.

Each landfill site in the study counties was visited, and data was collected concerning the size, location, and general characteristics of the site; method of disposal practiced; volume of refuse handled; collection system in operation; scheduling; kinds of landfill and transport equipment in use; type of equipment-sharing system practiced if any; and the cost requirement of the site.

Although the study counties are all rural, their topography, climate, and geographical settings are varied. The populations served by landfills in the counties range from about 130,000 to 2,800 (see Table 1). The largest cities in these counties are: in Graham County, the city of Safford with 6,100 people; in Habersham County, the cities of Cornelia with 3,020 people and Clarkesville with 1,300 people; in Cascade County, Great Falls with 65,000 people; in Lake County, Leesburg, with 13,550 people; in Leon County, Tallahassee, with 90,000 people; and in Catron County, the area of Reserve with 1,800 people.

The range of characteristics found in the study counties is shown in Table 2 which is a data summary compiled from the results of this investigation.

Table 1. POPULATION DENSITIES OF THE SIX STUDY COUNTIES

County	Population served (1975)	Land area, in km^2 ($miles^2$)	Density persons/km^2 (persons/$miles^2$)
Graham	11,900	8,702 (3,360)	1.4 (3.5)
Habersham	20,700	730 (282)	28. (73)
Cascade	20,000	6,923 (2,673)	3 (8)
Lake	74,450	3,012 (1,163)	25 (64)
Leon	130,000	1,735 (670)	75 (194)
Catron	2,800	17,862 (6,897)	0.2 (0.4)

Table 2. DATA SUMMARY OF THE SIX STUDY COUNTIES.

CHARACTERISTICS	Graham County, ARIZONA	Habersham County, GEORGIA	Cascade County, MONTANA	Lake County, FLORIDA	Leon County, FLORIDA	Catron County, NEW MEXICO
Number of landfills	5	2	6	7	7	2
Population served	11,900	20,700	20,000	74,450	130,000	2,800
Volumes processed in tonnes/yr (tons/yr)	5,300 (5,900)	26,500 (29,100)	14,965 (16,500)	114,848 (126,620)	210,100 (231,400)	3,200 (3,600)
Roads - type & condition	Good State & U.S. numbered highways. Gravel-surfaced access roads are good. No substandard structures.[a]	Good. No adverse grades or height, width, or weight limitations. Gravel-surfaced access roads.	Well-maintained State and U.S. numbered routes. Some gravel-surfaced in good repair. No adverse conditions, no substandard structures.[a] One winding gravel-surfaced forest road.	Good but circuitous routes. Some clay-sand access roads. No adverse gradients, no substandard structures.[a]	Good State and U.S. numbered routes. Some clay-sand roads which can be traveled at 40 m.p.h. when well maintained.	No substandard roads or structures.[a] Maximum grades of 10-12 percent and curvilinear routes. Winter travel is occasionally hazardous.
Fencing	All sites are fenced.	Both sites are fenced.	Ulm-fencing must be continuously replaced. Fort Shaw-no fencing. Remainder have fences.	All sites are fenced.	All sites are fenced.	Both sites are fenced.
Gates	No gates. Cattle guards at all sites.	Both sites have locked gates.	No gates at present.	All sites have locked gates.	All sites have locked gates.	Both sites have locked gates.
Storage containers (when fences and gates are closed) at landfills.	NO	NO	NO	NO	NO	YES

[a] Substandard is defined as inadequate in any or all of the following: (1) width of pavement; (2) height for clearance (i.e., bridge); (3) load-carrying capacity. Structure is defined as (1) bridge over 20-ft span or (2) culvert under 20-ft span.

Table 2 (continued). DATA SUMMARY OF THE SIX STUDY COUNTIES.

CHARACTERISTICS	Graham County, ARIZONA	Habersham County, GEORGIA	Cascade County, MONTANA	Lake County, FLORIDA	Leon County, FLORIDA	Catron County, NEW MEXICO
Daily Cover	YES, at 3 sites. At 2 sites-weekly. At 1 site bimonthly.	YES	NO - weekly	YES	YES at Spring Hill and Trash Dump. Periodic at others.	NO - weekly
Refuse collection	No County collection. Cities and public haul their own.	No County collection. Municipal pick-up, industries, and public haul.	No County collection. Contract haulers and public haul.	County-issued franchise collection and public haul.	No County collection. City of Tallahassee has franchise collection system. Public haul.	Public haul
Weighing of refuse	No - best estimate.	No - estimated by trench width.	No - estimated by Solid Waste Director.	No - estimated by attendant and operator.	At Trash Dump only, others by estimate.	No - estimated by landfill operator.
Type of landfilling	Trench-type	Progressive trench.	Trench-type except Ulm modified area. Sand Coulee - side-hill cut and cover.	Progressive trench-type.	Trench-type except Trash Dump which is area-type.	Trench-type
Annual land costs	$20.00/year/site $120.00	Free	Free	Free	Free	Free
Land	Bureau of Land Management land.	County owned	National Forest Private lands County lands	National Forest County owned County controlled City owned	County owned County controlled	National Forest
Equipment owning costs[b]	$11,920	$ 5,415	$ 650	$103,810	$65,490	$ 8,105
Equipment operating costs[b]	$ 9,130	$23,475	$ 1,100	$ 23,525	$90,435	$ 5,155
Labor & fringes[b] (fringe benefits @ 21% of labor)	$12,235	$27,370	$12,565	$152,500	$57,600	$15,510
Contract costs[b]	---	---	$32,510	---	$42,000	---
Total costs[b]	$33,405	$56,260	$47,125	$279,835	$255,525	$28,770
Cost per tonne (ton) processed	$6.30 ($5.66)	$2.12 ($1.93)	$ 3.15 ($ 2.86)	$2.44 ($2.21)	$1.22 ($1.11)	$8.99 ($7.99)
Hours of operation/day	24 hrs/7 days unattended	10 hrs/day/6 days attended	7 days/24 hrs unattended	10 hrs/6 days attended	9 hrs/6 days attended	9 hrs/1 day attended
Days/week attended	0	6	0	6	6	1
Number of attendants	0	2	0	7	7	2
Annual manhours (total)	2,080	8,320	Unavailable	Unavailable	Unavailable	936

[b]Annual costs.

The number of disposal sites located in the studied counties ranges from two in Catron County to seven each in Leon and Lake Counties. The present collection systems employed by municipalities in the counties under investigation range from contract collections to bring-your-own, with a predominance of the latter. The six counties under investigation maintain various schedules for disposal, pick-up, and transportation of refuse. Schedules for public admittance to the landfills range from 24 hours a day, 7 days a week to only 9 hours, 1 day a week. Data collected concerning miles between the sites in each county, highway travel time, quantities of refuse processed at the landfills, hours open to the public, days open to the public, and the operators' time utilization are included in Appendix A (Tables 7 - 12).

All landfills investigated are located on or near state and U.S. numbered routes. Other access and nearby roads are county roads in generally good repair.

All sites in use in the studied counties are generally acceptable to the area residents. At a few of the landfills, lack of consideration by users has necessitated supplemental maintenance and operating efforts by the county. Vandalism has not been uncommon. Signs at the entrances of the sites, at the landfills, and at bulk container sites have been used for target practice. Locked gates have been removed at some sites. Enclosure fences have been torn down and, at several sites, stolen repeatedly until the counties could no longer afford to replace them. A few sites have wind-borne litter scattered over a wide area; however, because the region is sparsely settled, complaints are few and intermittent. Sites where bulk containers are in use have received good public acceptance, although vandalism of bulk containers is common. (Damage is generally caused by bullet holes in the containers and occasionally by torching of the contents.)

As the site investigations progressed, it became evident that uncertainties exist everywhere in cost-keeping methods and records. Most of the data concerning operating costs had to be obtained verbally from the landfill operators. Daily and weekly log sheets are not maintained specifically for the sanitary landfill operations. Routine functions are usually performed by the operators in accordance with the equipment manuals and the manufacturer's recommendations. Quantities of fuel consumed and lubricants used are guesstimated by the operators, and supplies and disposable parts are obtained from local stores on an as-needed basis. Consequently, the costs developed in this study are a combination of data supplied by the landfill operators and equipment manufacturers and the experience of the Engineers.

A tabulation of land costs for the counties under study is shown on Table 2. The only county paying a yearly fee for landfill sites is Graham County, Arizona. In Graham County all the landfills are on Bureau of Land Management (BLM) land; the yearly fee is a nominal $20.00 per site. All other study counties obtained the landfill sites for free, either because they were county lands acquired from a previous operator, private lands that owners wanted filled, or National Forest Lands. Several counties are presently negotiating purchase of land for additional landfill sites.

Costs incurred in clearing of the landfill sites appear to be negligible. The Habersham County, Georgia sites have the most trees and heavy underbrush. Clearing costs for these sites are not maintained as such but are included as part of the normal operation of preparing fill areas and making trench. Leon County has several sites with underbrush and scattered pine trees. All other study sites are generally located in areas of sparse or light growth which can be easily pushed out of the way. All sites were apparently selected with an eye to keeping clearing of woods to a minimum, although many sites have woods or forests on several sides.

Development costs at all landfills involve expenses for fencing and preparing access roads into the sites. Fencing types are varied and range from chainlink fence in Leon County to wood-slat snow fence in Cascade County. Access roads into the sites generally have selected-materials surfacing in some form. Some sites have used crushed aggregate, some have used a sand-clay mixture, and others have used native on-site materials to construct the roads. All sites receive periodic maintenance from the county highway departments. A supplemental item at the landfills are the signs, some of which are purchased from private enterprise, but most of which are produced by the county highway sign department on an as-needed basis.

Labor costs incurred in landfill operation in the study counties vary depending on the number of sites and the particular requirements of each site. A tabulation of labor costs reported by respondents in the six counties is shown in Table 13 in Appendix B. For the most part, with the exception of Lake County, Florida, record keeping at the landfills is minimal.

The equipment employed by the six counties serves three basic functions: (1) handling waste, (2) handling cover material, and (3) performing landfill support functions. A wide variety of equipment was in use, ranging in age from 28 years old (and in good operating condition) to brand new with less than 20 engine hours.

Track-type landfill equipment is in use at all the sites. The machinery is equipped with either a dozer blade or a general purpose bucket. Some counties use wheel scrapers pulled by tractors and self-propelled wheel scrapers for covering. The transport equipment in general use throughout the six counties is a trailer and truck tractor.

Several counties incurred the costs of landfill and transport equipment purchased specifically for solid waste disposal. However, in many instances, the equipment used at the landfills was inherited from the county highway department. Some counties have highway department equipment on permanent loan to the landfill operation. Tabulations of landfill and transport equipment costs in the study counties are included in Appendix B (see Tables 14 and 15). In an effort to estimate equipment owning and operating costs, brochures of equipment manufacturers were researched and data was collected concerning purchase price, depreciation, normal hourly fuel consumption, normal periodic routine maintenance requirements, and anticipated repairs occasioned by normal wear and tear. These costs are given in Appendix B (see Tables 16, 17, and 18).

Utilizing the equipment owning and operating costs and the estimated amounts of solid waste being processed, costs per tonne (ton) landfilled were developed (see Table 19, Appendix B). In the absence of well-documented figures for volumes of solid waste processed, and operating costs (except for Lake County), volumes and costs were estimated on the basis of our observations. Wherever possible in the case studies volumes have been expressed in tonnes/yr (tons/yr) and costs have been presented in cost/tonne (cost/ton). However, cases in which waste volume data were received from the landfill operator in m^3 (yd^3) have been presented as received in an effort to avoid unnecessary distortion of the data. Where no waste volume data was available, estimates were made by the Engineer on the basis of physical field measurements and information supplied by the landfill operators. For comparison purposes all volumes have been converted to tonnage using an as-delivered density of 600 lbs/yd^3.

SECTION 3

CASE STUDIES

3.1 GRAHAM COUNTY, ARIZONA

Graham County is located in the southeast corner of Arizona. It has an area of 8,700 km^2 (3,360 $miles^2$) and varies in elevation from approximately 900 m (3,000 ft) on the desert floor to over 3,000 m (10,000 ft) in the mountain ranges. The Gila River generally bisects the county, flowing from east to west, and its valley is surrounded by the Pinaleno, Gila, Galiuro, and Peloncillo mountain ranges. The average annual rainfall in Graham County is between 20 and 36 cm (8 and 14 in), with the greater amounts falling at the higher elevations. Along the Gila River stretch the farming communities of Safford, Thatcher, Pima, Central, Bryce, and Eden. The county population is about 18,000 and its main industry is agricultural; cotton is the main crop, and cattle raising and pig farming are also economically important.

Graham County has five sanitary landfill sites: Artesia, San Jose, Central, Eden, and Ft. Thomas. All the sites have a desert topographical setting; the surrounding desert is mostly forage land for range cattle. All five sites are located on Bureau of Land Management (BLM) lands. For the most part, the routes serving the sites are good federal and state highways with county-maintained gravel roads leading into the landfills. All the roads are well maintained and in good repair.

Graham County does not operate a solid waste collection system. The communities of Thatcher and Pima operate 8-m^3 (10-yd^3) packer trucks. The City of Safford operates its own collection system and its own landfill. Private users of the county landfills haul their solid waste in pickup trucks and occasionally passenger vehicles. A minimum-security federal prison camp in the county uses a packer truck. The Forest Service also uses a packer truck to haul refuse from campgrounds during the summer.

The refuse disposed of at the sites is generally residential and agricultural. The size of the landfill sites and the daily volumes of refuse deposited (as reported by the operator on a best-estimate basis) are shown in Table 3.

The Graham County landfills are operated by special permit from the BLM on a yearly lease basis and are routinely monitored by the state. A trench-type landfill operation is practiced at all sites (see Figure 1). Routine operations common to all the sites are: spreading and compacting of the refuse, covering, making new trench if necessary, and general policing of the area. One equipment operator who also serves as the landfill operator travels from site to site with his equipment, performing the routine operations. Three of the sites (Artesia, Central, and San Jose) receive daily attention. Central and Artesia require the majority of the operator's time because of the volumes handled. Two of the sites (Eden and Ft. Thomas) are visited once a week by the operator. Approximately 85% of the refuse handled by the county is received by the three sites that receive daily cover.

The Graham County landfill operator has a demanding schedule for visiting and carrying on operations at the five sites. It is estimated from our observations that approximately 20 percent of his workday is required for transportation and about 80 percent is devoted to actual landfill operations.

The Graham County landfills all have fences and cattle guards. The sites are open 24 hours a day, 7 days a week but are unattended.

Graham County owns one piece of landfill machinery which is used for spreading and compacting refuse at all five sites. The machine is a Caterpillar D-5 tractor with dozer blade (see Figure 3), about 3 years old with an expected life of 6 to 8 years. It is transported between the landfills on a county-owned tractor and low-bed trailer. The tractor is a 1974 GMC of 11-tonne (12 1/2 ton) capacity, in good repair with an expected life of 6 to 8 years. The low-bed trailer has an 18-tonne (20 ton) capacity, is about 1 year old, and is in good repair. Available to the landfill operation when needed are other county-owned tractor-trailer combinations presently being used by the highway department.

Table 3. GRAHAM COUNTY LANDFILL SITES WITH SIZE AND REPORTED VOLUMES OF REFUSE

Landfill site	Total land area, in hectares (acres)	Approximate landfilling area, in (acres)	Annual volumes, in m^3 (yd^3)	Annual volumes,[a] in tonnes (tons)
Artesia	16 (40)	1 - 2 (2 1/2 - 5)	3,710 (4,850)	1,320 (1,450)
San Jose	16 (40)	2 1/2 (6 1/4)	2,140 (2,800)	760 (840)
Central	16 (40)	3 - 4 (7 1/2 - 10)	7,000 (9,160)	2,500 (2,750)
Eden	16 (40)	1 - 2 (2 1/2 - 5)	1,240 (1,620)	440 (490)
Ft. Thomas	4 (10)	1 (2 1/2)	850 (1,110)	300 (330)
Totals			14,940 (19,540)	5,320 (5,860)

[a] As-delivered density estimated to be 600 lbs/yd^3.

Figure 1. Progressive trench-type landfilling, Central landfill, Graham County, Arizona.

Figure 2. Signs at landfill entrance, Graham County, Arizona.

Figure 3. Caterpillar D-5 tractor with dozer blade and 18-tonne (20-ton) trailer, Graham County, Arizona.

Travel between the sites is generally no problem. Many of the routes are good state and federal highways; others are gravel-surfaced roads in good repair. There are no adverse grades or substandard structures along the equipment routes. One travel restriction is a state law prohibiting travel of over-sized vehicles on state highways between Friday evening and Monday morning except during emergencies.

Access to the individual sites is good and ample space has been provided at the sites for maneuverability; the off-loading areas can usually be negotiated easily. On rare occasions vehicles become stuck in loose sand at one or two of the sites; wet- and winter-weather operations are no problem.

The Graham County landfill sites are not equipped with employee facilities. Telephone communications must be made from nearby private residences. The Safford, Thatcher, and Pima Fire Departments provide fire protection for the sites.

Accurate cost records are not maintained for the Graham County landfills. From the data available it was determined that 5,300 tonnes (5,900 tons) of refuse per year are received by the six sites at a cost of $6.30/tonne ($5.66/ton) (see Appendix B tables). The disposal program costs less than $3.00 per capita per year for the area served.

3.2 HABERSHAM COUNTY, GEORGIA

Habersham County is situated in the northeastern corner of Georgia on the eastern rolling foothills of the Appalachian Mountains. The northerly and easterly portions of the county are occupied by the Chattahoochee National Forest. The average annual rainfall varies beween 130 and 140 cm (50 and 55 in). The county has a population of about 20,700 people. The principal cities, Clarkesville and Cornelia, are textile manufacture-oriented. Other industries in the county include timber/lumber, agriculture, recreation, and poultry processing.

Habersham County owns and operates two sanitary landfill sites--Cornelia and Clarkesville. Both landfills are situated in an open rural area surrounded by fields and woods. At present the county has no other sites or bulk container stations. A plan for using bulk container stations in remote areas of the county has been suggested and perhaps will receive due consideration in the future.

The first site inspected was the Cornelia landfill located off County Rte. 2403 (old Cleveland Road). The landfill access road is gravel-surfaced, about 5.5 m (18 ft) wide, and in good condition. The overall site area is approximately 22 hectares (54 acres) with about 10 hectares (26 acres) in landfilling process. Daily volumes of refuse received at Cornelia, as estimated by the operator, are between 160 and 200 m^3 (200 and 260 yd^3) (estimates based on trench widths). The refuse consists of residential, agricultural, and commercial wastes. Sewage sludge from an adjacent wastewater treatment plant is also deposited in the landfill but not in the same trench as the solid waste. This site is fairly well maintained, although, at times insufficient cover is used on the refuse and flies become a minor nuisance. During prolonged dry spells dust is also a problem.

The second Habersham County site is located in an underdeveloped corner of the City of Clarkesville near several auto graveyards. It is situated on a 5.5-m (18-ft) wide asphalt-surfaced county road with a gravel-surfaced access road. The total site area is about 32 hectares (80 acres) with about 9 hectares (22 acres) used and in the process of being landfilled. Daily volumes of refuse received average between 80 and 110 m^3 (100 and 140 yd^3), as estimated by the operator. The refuse consists of residential, agricultural, and commercial wastes with some sludges from a textile treatment process. This site is well maintained and has ample supplies of cover material for all operations.

Habersham County does not operate a collection system. The communities of Cornelia and Clarkesville have municipal pick-up using 5-1/2- to 8-m^3 (7- to 10-yd^3) packer trucks. The several county-based industries use van-type and stake-body-type vehicles. Individual users transport their refuse using pickup trucks, dump trucks, and passenger vehicles.

The operations at the two Habersham County sites are quite similar. Both sites are open and attended 10 hours a day, 6 days a week. The gates are locked when an attendant is not on site. No provisions are made for accepting refuse when the landfill is closed. The landfilling is a progressive trench-type operation where trench excavation is used to cover the daily

solid waste accumulations (see Figure 4). Dead animals are accepted with normal residential trash. Compaction and covering are performed daily (see Figure 5). In general, the covering operation is excellent at Clarkesville and good at Cornelia. Routine inspections are performed by the State Department of Natural Resources.

Habersham County uses a new Caterpillar D-7 tractor with dozer blade for operations at the Cornelia and Clarkesville sites. At the time of our investigations the machine had less than 20 hours on the clock and an expected life of 8 years. On loan from the county highway department and also in use at the landfills are: a Caterpillar D-6 tractor with dozer blade (cable) which was purchased in 1947; a Caterpillar D-7 tractor with 5-1/2-m^3 (7-yd^3) wheel scraper (approximately 27 years old); a backup Caterpillar D-7; and a self-propelled (elevating type) wheel scraper International E-200 (approximately 10 years old).

The county presently transports the wheel scrapers between the two sites with a 1975 GMC truck tractor low-boy trailer combination of 32-tonne (35-ton) capacity. Both the tractor and trailer are in excellent condition. A 1971 Ford tractor and low-boy trailer (on loan from the highway department), is also used for transport between the sites. The county landfill and highway departments appear to have a satisfactory working arrangement for the use of transport equipment.

Habersham County equipment travels over 13 km (8 miles) of good highways. There are no adverse grades or structures posted with height, width, or weight limitations along the traveled route. All equipment when fully loaded is well within the maximum state highway load limits. Adverse site operating problems have been minor--such as slash- and brush-carrying trucks getting bogged down in the mud while dumping at the rear of the landfill. During extremely wet weather, covering must sometimes be delayed for several days because of the mud. At the trench areas, maneuverability for vehicles is generally good. Landfill dust disturbed by vehicles is an occasional problem.

There are no employee facilities at either of the Habersham County sites. Telephone communication is available within 1/2 km (1/4 mile) of each site.

Accurate cost records are not maintained at the Habersham County landfills. On the basis of available information it is estimated that Habersham County handles approximately 26,500 tonnes (29,100 tons) of refuse per year at a cost of $2.12/tonne ($1.93/ton) (see tables in Appendix B).

Figure 4. Trench-type landfill, Cornelia site, Habersham County, Georgia.

(a)

(b)

Figure 5. Operations at Clarkesville sanitary landfill, Habersham County, Georgia: (a) spreading and compacting; (b) loading cover material.

3.3 CASCADE COUNTY, MONTANA

Cascade County is located in the central northwest part of Montana in the Great Plains region of the northwest United States. The Little Belt Mountains in the southeast corner of the county contain a portion of the Lewis and Clark National Forest. The Missouri River generally bisects the county from southwest to northeast. The average annual rainfall in the region is about 30 cm (12 in). The city of Great Falls is the major urban center, with a population of about 65,000 of the county's 85,000 people. Most of the small communities in the county are stretched out along U.S. traffic routes 89 and 91. Major industries in the county are agricultural--principally, range land for cattle, grain crops, and to some extent recreation in the National Forest. Around the city of Great Falls, there are several other industries of which Anaconda Copper Company and Malmstrom Air Force Base are the largest.

Cascade County has six sanitary landfill sites: Vaughn, Fort Shaw, Ulm, Monarch, Stockett, and Sand Coulee. Topographically, Vaughn, Fort Shaw, and Ulm are located on grazing open range land; Monarch is on Lewis and Clark National Forest Land; Stockett is on top of a low hill in a former coal mining area; and Sand Coulee is in a coulee adjacent to a former coal mining area.

The routes serving the sites are all good federal, state, and county highways. Vaughn, Ulm, and Sand Coulee are located on paved county highways, Fort Shaw and Monarch are on gravel-surfaced roads off paved highways, and Stockett is on a selected-materials-surfaced road off a paved county highway.

Cascade County has no collection system. Several contract haulers collect refuse in various parts of the county; ranchers and farmers generally use pickup trucks for carting refuse; and smaller homesteads and residences occasionally use passenger vehicles. Dump trucks of the 4- to 6-m^3 (5- to 8-yd^3) size and 1.4-tonne (1-1/2-ton) stake-bodied trucks are also used.

The refuse deposited at the Cascade County sites is generally residential-agricultural with some commercial waste. Dead animals are taken for a fee and under special arrangements, but the county tries to discourage the practice. The daily volumes for each site, estimated by the Solid Waste Director on the basis of the population using the landfills are: Vaughn, 11.2 tonnes (12.3 tons); Fort Shaw, 6.2 tonnes (6.8 tons); Ulm, 6.4 tonnes (7 tons); Monarch (summer), 2.1 tonnes (2.3 tons); Stockett, 7.4 tonnes (8.3 tons);

and Sand Coulee, 7.7 tonnes (8.5 tons). The county keeps its landfills open 7 days a week, 24 hours a day to minimize vandalism which in the past has resulted in the removal of gates and fences. All sites are unattended.

The Vaughn landfill is the only site operated by Cascade County; the other five sites are operated by a local contractor under a contract with the county that includes spreading, compacting, and covering of the refuse. Trench digging, when necessary, is paid for on a time-and-materials basis. A landfill operator visits each of the sites once a week to perform the routine landfill operations including placement of cover.

Operations began at the Vaughn Landfill in August 1975. The Vaughn site is a modified area-trench operation using a sidehill-trench cut-and-cover method of landfilling. The objective at Vaughn is to raise the ground elevation to that of the adjacent occupied land.

The Fort Shaw site is a trench-type landfill. Because the site is open and treeless, wind scatters refuse and litter and causes cleanup problems. The off-loading area is easily negotiated. Site conditions in wet weather are not too adverse. However, covering becomes a problem during severe and extended sub-zero temperatures because stockpiles freeze.

Disposal practices at the Ulm* landfill site are perhaps the poorest in the county. Vandalism is prevalent and fencing must be continuously replaced. The wind scatters litter across the fields. Indiscriminate dumping, which at times blocks the entrance adjacent to the highway, encourages others to dump at the same place thereby compounding the problem. Trenching cannot be performed at Ulm because the area has already been landfilled; a modified area-type operation is practiced instead. Cover material is obtained from a borrow area about 300 m (1,000 ft) away.

The Monarch+ landfill is a trench-type operation. Bears in the National Forest raid the landfill at night, cart plastic bags into the nearby woods, and feast on the contents. The practice of weekly cover at the site is not looked upon favorably by the National Forest.

The Stockett landfill is situated on a hilltop in a former coal mining area; trench-type landfilling is practiced at the site (see Figure 6). The access road into Stockett is narrow, winding, and in poor condition, but maneuverability on the site is good and the off-loading area is easily negotiated. Wind is a constant problem and dust is a nuisance.

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*The Ulm landfill was closed and replaced by the county in February, 1976.

+The Monarch site was closed in April, 1976. Bulk containers were placed at the site.

Figure 6. Stockett landfill, Cascade County, Montana.

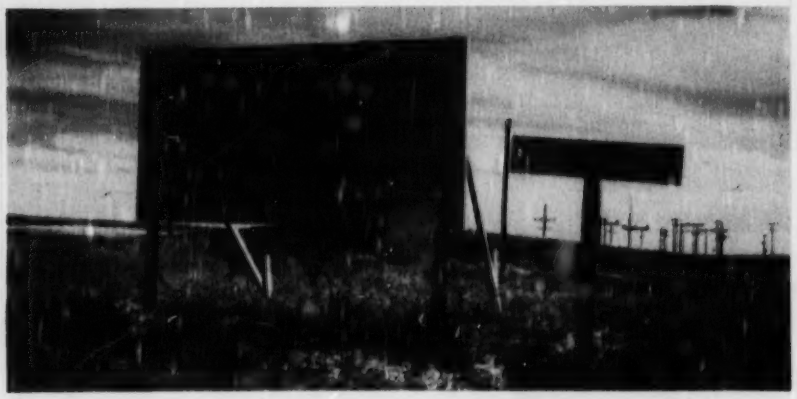

Figure 7. Typical signs at landfills in Cascade County, Montana.

Figure 8. Contractor's transport equipment, Cascade County, Montana.

The Sand Coulee landfill is operated in a long narrow coulee. It is an old dump, dating back to when the area was a coal mining town, that has since been converted to a landfill. The lower portion of the coulee is the present landfill. Sand Coulee is a sidehill-cut-and-cover operation. Maneuverability in the landfill is somewhat restricted because of a stream on one side and a hillside on the other. The landfill area is also very close to the road. Cover is in short supply and debris often ends up in the nearby stream. Frequently, refuse is indiscriminantly dumped outside of designated areas and landfill signs (see Figure 7) are torn down. Continuing efforts by the county are necessary to educate the landfill users on procedures and policies.

Cascade County has been operating the Vaughn landfill since August 1975. They presently own a Case 1000-D tractor with a 1-m^3 (1-1/2-yd^3) bucket for use at Vaughn. The machine was purchased in used condition and is about 7 years old; its remaining expected life is between 2 and 3 months. It was to be traded around October 1975 on a new tractor specified as a Caterpillar D-6 or equivalent with a 2-m^3 (2-1/4-yd^3) general-purpose bucket.

The local contractor who maintains the other five Cascade County sites uses one piece of equipment, which appears to be about 6 years old and in good repair. It is equipped with a 1-m^3 (1-1/2-yd^3) general-purpose bucket.

Cascade County uses a new (approximately 2,000 miles on the odometer) 2-tonne (1-1/2-ton) International tractor which hauls a new tilt-bed trailer of 23-tonne (25-ton) capacity. The life of the truck-tractor is estimated at 10 years and the life of the tilt-bed trailer, at 15 years. Also available to the solid waste operation on an emergency basis is a tractor and low-bed trailer from the highway department. The local landfill contractor uses an International 2-tonne (2-1/2-ton) truck tractor and a 23-tonne (25-ton) tilt-bed trailer to haul his equipment for the five sites (see Figure 8), and has other tractor-trailer rigs at his disposal.

Cascade County's highways and gravel-surfaced roads are in good repair; during dry weather they are dusty and require palliative treatment. However, no adverse travel conditions or substandard structures are evident along the equipment-hauling routes. The loaded vehicles are well within state allowable maximums.

There are no employee facilities at any of the Cascade County sites. All sites have volunteer fire departments within easy driving distance. Routine landfill inspection is performed by the state.

It is estimated on the basis of available information that Cascade County handles a total of 14,965 tonnes (16,500 tons) per year at a cost of $3.15 per tonne ($2.86 per ton) (see tables in Appendix B). Cost accounting records at the sites are minimal.

Cascade County is planning to close the Monarch landfill site in the near future and replace it with a 31-m^3 (40-yd^3) bulk container located in the Belt area. A plan to replace the Stockett and Sand Coulee sites with bulk containers is also under consideration. The County is presently looking for a new location to replace the Ulm site, which has apparently reached landfill capacity; this replacement is receiving priority consideration.

3.4 LAKE COUNTY, FLORIDA

Lake County is situated in central Florida. Ocala National Forest occupies a large portion of the northern area of the county. Citrus fruit production together with some cattle ranching and other agricultural crops make up the area's economy. There are approximately 1,400 named lakes in Lake County covering 523 km^2 (202 $miles^2$) of its total 3,012 km^2 (1,163 $miles^2$). The average rainfall is about 130 cm (50 in) per year. The elevation of the area ranges from 16 to 89 m (53 to 292 ft) above sea level. There are 14 incorporated areas in the county with a total population of 43,200. The county has a permanent population of about 88,000. The populations of some of the large cities are: Leesburg, 13,550; Eustis, 7,200; Mount Dora, 5,150; Clermont, 4,000; and Tavares, 3,910.

Lake County presently operates seven sanitary landfills. Several other sites were closed in the past because they had reached landfill capacity and the county did not want to mound above the adjacent terrain. Several more sites are now almost to the point of capacity. The county is actively considering phasing out its small landfills (Astor and Paisley) and establishing a central sanitary landfill with strategically located attendant transfer stations.

The seven sites in operation at present are: Umatilla, Astor, Paisley, Lady Lake, Stuckey, Log House, and Astatula. The Umatilla landfill is owned by the city of Umatilla and operated by Lake County. Recently, the city requested that the county vacate the site because it has been accept-

ing solid wastes generated outside the city limits. The largest of the seven landfills is Astatula which received approximately 146,450 m^3 (191,560 yd^3) of solid waste in 1974. These figures are estimates based on information reported by the operators and attendants. There is no accurate means of determining the exact volumes of solid waste buried at these sites. The smallest landfill appears to be the Astor site in the Ocala National Forest; Astor is rapidly nearing capacity.

Lake County does not operate a collection system. Most collection is performed by franchise issued by the county. The county residents that do not use franchised collectors haul their wastes in passenger vehicles and pickup trucks.

The Lake County landfills are open for disposal 6 days a week for 10 hours a day. An attendant is on duty during this time to direct unloading and take care of general cleanup. The sites are fenced and access is controlled by gates. User fees are charged for disposal by franchise haulers and all trucks; automobiles using the landfills are not charged for disposal at the present time. When the county converts to transfer stations, user fees may be extended to include automobiles. No provisions have been made for accepting refuse when the gates are closed. Signs at the entrance state operating conditions and hours of operation (see Figure 9). Shelters have been erected at the sites for the attendants.

The basic method of landfilling at the Lake County sites is the progressive trench-type (see Figure 10). Cover is applied daily. The trenches are excavated with a dragline; the spreading, compacting, and covering of the refuse is performed by track-type bulldozers. All the sites are fairly well maintained. After an area has been completely landfilled it is contour-graded and planted with native grasses.

Lake County has eight pieces of landfill equipment in operation. The landfill equipment used at the Astatula site includes a Koehring 1-m^3 (1-1/4-yd^3) dragline and an International TD-25-C crawler tractor. At Lady Lake an older Northwest dragline excavates the trench and a bulldozer spreads, compacts, and covers the daily cells. A Caterpillar 933 traxcavator is used at Astor. The Log House and Stuckey sites share two pieces of equipment--an International TD-15 bulldozer and an International 175B loader. The Paisley and Umatilla sites share one International TD-15 bulldozer. In an emergency, equipment is available from the county highway department.

Figure 9. Typical signs at landfills in Lake County, Florida.

Figure 10. Trench-type landfilling at Lady Lake, in Lake County, Florida.

For hauling landfill equipment between sites, Lake County uses a 17-year old truck tractor low-boy trailer rig (gasoline-powered) of about 23-tonne (25-ton) capacity. The equipment is in fair to poor condition and its expected remaining life cannot readily be determined. One to two years of use may remain. Backup transport equipment is available from the county highway department. A pickup truck for the operator is assigned to each landfill.

All the roads leading to the landfills in Lake County are in good condition. Some of the access roads are surfaced with a clay-sand mixture for short distances. Although many of the routes between landfills are circuitous because of the many bodies of water throughout the county, travel is fairly swift. A round trip of all the sites exceeds 380 km (200 miles). There are no adverse gradients or substandard structures on any of the landfill routes. Fire protection at the sites is provided by stockpiles of soil and local volunteer fire departments within easy driving distance of the landfills.

Lake County maintains monthly expenditure logs which tabulate the equipment hours, fuel, oil, grease, repairs, and other equipment costs, total salaries paid, total field costs, cubic yards landfilled, and cost per cubic yard to landfill (see Table 4). This accounting method is the most sophisticated of any used at the sites studied; however, the capital costs of the equipment and the fringe benefits for employees are not included in these calculations. Lake County estimates their disposal costs at $1.65/tonne ($1.50/ton). Our developed costs for Lake County including fringe benefits and equipment owning costs are $2.44/tonne ($2.21/ton).

3.5 LEON COUNTY, FLORIDA

Leon County is located in the Florida panhandle. The Apalachicola National Forest occupies a large area in the western part of the county. Portions of Leon County are also in the Miccosukee Hills, the Tallahassee Hills, and the Karst coastal plain. The average annual rainfall is 142 cm (56 in). Tallahassee, a city of 90,000, is the county seat; it is also the State Capital, and the home of Florida State University, Florida A. & M. University, and Tallahassee Community College. With a population of about 130,000, Leon County is not a large industrial or manufacturing area; two of the larger industries are a crate mill and a mobile home manufacturer.

Table 4. EXPENDITURES REPORT FOR SEPTEMBER 1975 AT LAKE COUNTY, FLORIDA SANITARY LANDFILL[a]

Landfill site	Hours Machines Operated	Fuel, Oil, Grease and Repairs	Other Costs	Total Salaries Paid[b]	Total Field Cost[c]	Volume of refuse buried, in m^3 (yd^3)[c]	Cost per m^3 (per yd^3)[c]	Volume in tonnes (tons)	Cost per tonne (cost/ton)
Astatula	150	$ 327.20	$ 228.58	$ 2,609.68	$ 3,165.46	10,650 (13,932)	$0.30 ($0.23)	3,792 (4,180)	$0.83 ($0.76)
Lady Lake	88	$ 190.75	$ 228.57	$ 1,515.47	$ 1,934.79	4,370 (5,716)	$0.44 ($0.34)	1,555 (1,715)	$1.24 ($1.13)
Log House	40	$ 201.88	$ 228.57	$ 1,588.18	$ 2,019.03	3,375 (4,414)	$0.60 ($0.46)	1,201 (1,324)	$1.68 ($1.52)
Astor	39	$ 367.32	$ 228.57	$ 874.00	$ 1,469.89	1,640 (2,140)	$0.90 ($0.69)	582 (642)	$2.53 ($2.29)
Paisley	54	$ 180.35	$ 228.57	$ 619.10	$ 1,028.52	2,055 (2,690)	$0.50 ($0.38)	732 (807)	$1.40 ($1.27)
Stuckey	113	$ 457.41	$ 228.57	$ 1,751.17	$ 2,437.95	2,180 (2,858)	$1.12 ($0.85)	777 (857)	$3.14 ($2.84)
Umatilla	107	$ 235.47	$ 228.57	$ 1,543.10	$ 2,007.14	3,830 (5,000)	$0.52 ($0.40)	1,361 (1,500)	$1.47 ($1.34)
Monthly totals	591	$ 1,960.38	$ 1,600.00	$ 10,502.00	$ 14,062.78	28,100 (36,750)	$0.50 ($0.38)	10,000 (11,025)	$1.41 ($1.28)
Fiscal year cumulative totals	6,320	$51,941.67	$15,610.00	$122,160.10	$189,712.47	322,710 (422,067)	$0.59 ($0.45)	114,848 (126,620)	$1.65 ($1.50)

[a]Submitted (by Lake County) to Florida Department of Health and Rehabilitative Services on Sanitary Landfill Form C-3.

[b]Does not include fringe benefits.

[c]Volumes and costs furnished by Lake County. Costs do not include equipment depreciation.

Leon County operates two large and five small landfill sites--all of which are presently in various phase-out stages. The five small landfills, scattered in rural areas of the county and generally surrounded by woods, are nearing capacity and are scheduled to be converted to bulk container disposal sites within the next two to three months. These landfills are: Lakewood, Woodville, Miccosukee, Tram Road, and Fort Braden. Walls and embankments to create off-loading areas for the bulk containers are presently under construction at these sites (see Figure 11). The two large landfills, Spring Hill and Trash Dump, are situated just outside the city limits. Spring Hill handles putrescibles (generally residential wastes) and Trash Dump is used only for demolition--trees and stumps, broken pavement, and wasted earthwork. Spring Hill has an area of 40 hectares (100 acres) of which 36 hectares (90 acres) have been used. Trash Dump has an area of 24 hectares (60 acres) of which about 22 hectares (54 acres) have been used. A proposed new sanitary landfill of approximately 183 hectares (452 acres) is presently in the design and acquisition stage. The new landfill should be operational during the early part of 1976.

Leon County, Florida does not operate a collection system. The city of Tallahassee has a franchise collection system. County residents using the smaller landfills use pickup trucks and passenger vehicles to transport their solid waste for disposal. User fees for disposal at the new central landfill are presently under consideration by the county.

All the Leon County landfills have fences and locked gates. They are open 6 days a week, 9 hours a day. Signs at the entrances indicate the regulations and hours of operation, but the county has had trouble with vandals entering the sites during off-hours. No provisions have been made for solid waste disposal outside the gates when the landfills are closed.

There is no accurate method of determining the volumes of solid waste handled at any of the landfills except at Trash Dump, where a scale is used to establish the tonnage deposited. Trash Dump processes an average of 10,900 tonnes (12,000 tons) per month. Monthly volumes estimated for the five small landfills are: Lakewood, 2,675m^3 (3,500 yd^3); Woodville, 1,900 m^3 (2,500 yd^3); Miccosukee, 765 m^3 (1,000 yd^3); Tram Road, 1,680 m^3 (2,200 yd^3); and Fort Braden, 1,760 m^3 (2,300 yd^3). The Spring Hill site processes an average of 9,770 m^3 (12,780 yd^3) monthly.

Trench-type landfilling is practiced at all the sites except Trash Dump. Cover material for Trash Dump is in limited supply. The Spring Hill and Trash Dump landfills are maintained daily. The smaller sites receive periodic attention and sometimes have a problem with gulls being attracted to the uncovered refuse. When these sites are phased out in the next two to three months, they will be contour-graded and vegetated with grasses.

(a)

(b)

Figure 11. Construction for bulk container sites in Leon County, Florida: (a) bin wall and pad at Woodville; (b) typical bin (container) at Fort Braden.

Leon County owns a Rex Trashmaster Compactor, a Caterpillar D-8 track-type bulldozer, and a Link Belt 98 dragline on crawler tracks of about 1-m^3 (1-1/2-yd^3) capacity. This equipment is used for operations at the Spring Hill landfill. It was purchased in December 1970 and is in good condition. Its expected remaining life ranges from about 3 years for the Trashmaster to 10 years for the dragline. A 32-year old Caterpillar D-7 bulldozer is also owned and used by the county at its other landfills. An Allis-Chalmers HD-21 is stationed at the Trash Dump site. A landfill contractor uses a Caterpillar D-8 crawler tractor at Trash Dump and services the five satellite landfills with a small crawler tractor.

Leon County has no transport equipment assigned to the solid waste department. Whenever landfill equipment must be moved, transport vehicles are borrowed from the county highway department. The landfill contractor operating Trash Dump and the other sites appears to have ample transport equipment.

The highways in Leon County are, for the most part, good state and U.S. numbered routes. Several of the county roads serving the landfills are composed of native hard-packed clay and sand and are maintained periodically with a motor grader. Speeds of 64 km (40 miles) per hour can be attained when these routes are in good condition. The loaded transport vehicles are within state maximum-load limits.

Fire protection for the two large landfills is provided by the Tallahassee Fire Department. The Forest Service and small volunteer fire departments serve the small outlying landfills.

As in most of the counties studied, record keeping for solid waste disposal operations is minimal. On the basis of estimates and available information, it was determined that Leon County handles approximately 210,100 tonnes (231,400 tons) of refuse per year at a cost of $1.22 per tonne ($1.11 per ton) (see Appendix B tables).

3.6 CATRON COUNTY, NEW MEXICO

Catron County is covered in large part by the Gila National Forest which rises above the desert of southwestern New Mexico and serves as a huge watershed for the Great Southwest region of the United States. The mountain ranges in Catron County include the Mogollone, the Tularosa, and the Black Range. The average annual rainfall in the region is between 20 and 64 cm (8 and 25 in), with the greater amounts falling on the higher ele-

vations. The county is sparsely populated, containing approximately 2,800 people; however, from mid-May to mid-September the population swells with tourists. The industries of the county are timber, forage or range land, and recreation.

Catron County operates two sanitary landfills, both of which are located in the Gila National Forest--one in the Glenwood Forest Ranger District and one in the Reserve District. The landfills are situated in mountain foothills and surrounded by scattered pinon and ponderosa pine trees. They are operated under National Forest Service special use permits which can be rescinded for violations of permit requirements.

Catron County does not operate a collection system. Each landfill is served by several bulk container stations, and users transport their own refuse to either the landfill sites or the container stations. The most common vehicle used for hauling is the 0.5- to 0.7-tonne (1/2- to 3/4-ton) pickup truck. The county periodically transports the 15-m^3 (20-yd^3) collection boxes to the landfills for disposal.

Catron County maintains a pick-up schedule for its bulk containers and a specified date when the landfills will be open. The Glenwood and Reserve landfills are open only on Saturdays for a 9-hour period. During this time, users can approach the trench and off-load directly into it at a location specified by a posted sign. When the gates are locked, users must deposit refuse in a 15-m^3 (20-yd^3) bin with hinged wire mesh covers, which is stationed outside of the gates at each site (see Figure 12). In addition to this bin, the Glenwood landfill is served by 2 other bulk container stations--Alma and Mogollone--and the Reserve Site is served by 4--Luna, Rancho Grande, Aragon, and Cruzville. The containers at these sites are available to the public 24 hours a day, 7 days a week. Periodically the bulk containers are transported to the landfills and emptied as follows: the operator first empties the container stationed outside of the landfill gate. He transports that mounted empty container to the first station where he exchanges it for the full box. The full box is then transported to the landfill and emptied, and the procedure is repeated until all stations have been serviced. The last emptied container is repositioned outside of the landfill gate.

The Glenwood landfill is situated on U.S. 180, a bituminous concrete highway. The overall site area is approximately 4 hectares (10 acres) with 2 hectares (5 acres) being actively used for landfilling. Daily volumes deposited, as estimated by the landfill operator, are between 12 and 19 m^3 (15 and 25 yd^3). The refuse consists of residential, agricultural, and some commercial wastes. In the spring when volumes increase, slash is sometimes a problem. Dead animals are landfilled occasionally when arrangements are made with the operator.

Figure 12. Bulk storage container stationed at the Glenwood landfill, Catron County, New Mexico.

Figure 13. The Reserve landfill site, Catron County, New Mexico.

Figure 14. Massey-Ferguson bulldozer at the Glenwood landfill, Catron County, New Mexico.

Trench-type landfilling is practiced at Glenwood and the refuse is compacted and covered daily. Site characteristics are good in terms of making trench, stockpiling cover material, dumping the bulk containers, disposal by private users, compacting, and covering. Vectors are controlled by cover materials, and the site appears to be well maintained.

Access to the Glenwood landfill is relatively easy because of its location just off a federal highway. Maneuverability on the site is generally good in both dry and wet seasons. No winter operating problems have occurred. Fire protection is provided by the Glenwood Fire Department, which is approximately 3 km (2 miles) away.

The Reserve landfill is located off state highway 12 on the Hudson Ranch Road, a 6-m (20-ft) wide gravel-surfaced road in good condition. The total site area is about 32 hectares (80 acres); the fenced landfill area is about 3 hectares (8 acres). Daily volumes deposited are estimated to be between 15 and 23 m^3 (20 and 30 yd^3), composed mostly of residential refuse. In the fall and spring when landowners clear portions of their land, slash volumes increase and sometimes become a problem. Dead animals are landfilled when arrangements are made to receive and cover them.

Trench-type landfilling is practiced at the Reserve site (see Figure 13). The operator reported no major problems in the landfilling process. A drainage problem existed at the time of our inspection; however, a review of the site indicated that this problem can be solved with one or two days' work with equipment. Also during our inspection, a fair amount of debris was protruding from the cover material on the landfill; this problem could be solved with additional cover material and compaction. Blowing litter is often a problem at this site.

Access to the Reserve site and access to and from the off-loading areas are good. Fire protection is provided by on-site stockpiles of cover material and by the Reserve Fire Department located 3 km (2 miles) away.

Catron County owns two 60-hp Massey-Ferguson tractors with dozer blades (see Figure 14). One tractor is stationed at each landfill site and is used specifically for that site. The machinery is approximately 2 years old; the piece at Glenwood has an estimated remaining life of 5 years, and the piece at Reserve has a remaining life of 2 years.

Catron County owns two 0.7-tonne (3/4-ton) pickup trucks and three trailers for transporting nine bulk containers to the landfills for disposal. The loading/unloading procedure for emptying the bulk containers

Table 5. ESTIMATED MONTHLY COSTS OF SANITARY LANDFILL OPERATION AT RESERVE, NEW MEXICO (CATRON COUNTY) FOR 1975[a]

Item	Cost per month
Fuel for sanitary landfill truck--1,135 liters (300 gal)	$ 165.00
4.7 liters (5 qt) of oil (for oil change)	4.25
1 oil filter for oil change	4.00
1 set of rear tires for every 12,870 km (8,000 miles)	20.00
1 set of six tires for every 25,740 km (16,000 miles)	60.00
1 lube job every 6,440 km (4,000 miles)	1.50
General maintenance on truck and trailer (tune-ups, etc.)	100.00
Depreciation on truck and trailer	125.00
Diesel fuel for tractor to cover landfill--76 liters (20 gal)	8.00
Diesel fuel for tractor to dig trench for landfill--227 liters (60 gal)	24.00
General maintenance for tractor	330.00
Depreciation on tractor	400.00
Landfill operator labor cost	418.00
3 days' labor for 3 men using tractor and grader to excavate trench for landfill	216.00
Diesel fuel for grader to dress access roads and dig trench--150 liters (40 gal)	16.00
TOTAL MONTHLY COST	$1,891.75

[a]As furnished by Catron County, New Mexico.

[b]Approximate mileage for sanitary landfill truck--3,220 km (2,000 miles) per month. Gasoline used is 284 liters (75 gal) per week or 1,135 liters (300 gal) per month. Mileage averaged is 3 km/liter (7 miles/gal) with load.

SECTION 4

COMPARISON OF RURAL LANDFILL OPTIONS

Comparisons among the rural landfill systems included in this study cannot be made easily or systematically because of the diversity found among the operations being practiced. Only two of the systems can be categorized in terms of operation; the others combine elements from several kinds of landfill operation. The extent of equipment-sharing among landfills in the six counties ranges from exclusive sharing in Graham County to no sharing in Catron County, which is a bulk-container transfer station disposal system. Habersham County transports one and sometimes two pieces of landfill equipment between its two sites. Cascade County operates one landfill using one piece of equipment; the other five Cascade County landfills are operated by a contractor who uses one or two pieces of equipment at all the sites. Both Lake and Leon Counties have permanently stationed landfill equipment at their large-volume sites and share one piece of equipment between small-volume sites on a daily basis. At the time of this study, Leon County was in the process of phasing out the small landfills and converting to bulk container transfer stations. Lake County had prepared studies and taken preliminary steps toward replacing two of its smaller landfills, which were approaching capacity, with transfer stations.

Depending on location, site conditions, population density, and volumes of waste generated, each of these systems has some advantages and disadvantages. Graham County, Arizona provides the lowest level of service at a cost of $3.00 per resident per year. With one operator using one piece of landfill equipment and one piece of transport equipment to operate five scattered landfills, the majority of the operator's time is, of course, devoted to the more active landfills; the low-volume sites receive only periodic attention. All sites are unattended and are open 24 hours per day 7 days per week. The major disadvantage of this system is the length of time that the refuse lies uncovered allowing the refuse to be scattered by the wind. The second disadvantage is

the amount of time the operator spends traveling between the sites. For Graham County it is estimated that 20 percent of his time is spent in transport and 80 percent in actual landfill operations. Thirdly, the term "sanitary landfill" cannot be applied to the smaller sites in Graham County because the refuse is not covered on a daily basis.

Of course an equipment-sharing system offers the advantage that expensive equipment is utilized to its fullest extent, as opposed to a system in which several pieces of equipment are used and must sit idle much of the time. Efforts to upgrade the Graham County system would mean increasing costs. Disposal costs at the time of the study are estimated at $6.30/tonne ($5.66/ton). Additional equipment and labor, or overtime for the present staff, would be required to improve the conditions in Graham County and would mean a more expensive operation.

The Habersham County, Georgia solid waste disposal operation maintains about five times as many employees and four to five times as many pieces of landfill equipment as the Graham County system. It is classified as a "sanitary landfill" operation because daily cover is performed. Habersham County practices some equipment-sharing between its two landfills but also has landfill equipment permanently assigned to each site. This equipment sits idle for at least 4 hours a day.

Attendants are on-site at the landfills 10 hours a day, 6 days a week--a measure that has discouraged scavenging, vandalism, and indiscriminant dumping at the landfills. One disadvantage of the Habersham County system is that the remote areas of the county are not adequately served by the two landfills, which are located 13 km (8 miles) apart. Residents of the northern sections of the county must travel up to 64 km (40 miles) round trip to use the landfills. Bulk container stations should be considered in the future to facilitate waste disposal in the more remote areas of the county. At present the residents of these areas use other disposal methods such as burning or filling of hollows. The introduction of bulk container stations in these areas will encourage more residents to use the disposal facilities.

Habersham County handles approximately five times as much waste as Graham County at less cost/tonne, as would be expected. It was determined that the cost of refuse disposal in Habersham County is $2.12/tonne ($1.93/ton).

Landfilling operations in Cascade County, Montana at the time of this study were performed by a contractor at all but one of the sites. The contract operation could be considered a form of equipment sharing because the contractor shared several pieces of equipment among five landfills. The operation cannot be considered sanitary landfilling at these sites because routine operations are performed once a week. The contractor's duties include compaction and covering; he receives hourly compensation for digging additional trench when it is required.

The Cascade County sites are open to the public at all hours, seven days a week and are not attended. One major disadvantage of the operator's weekly visits is that litter is carried by the constant winds and scattered in all directions. Designated off-loading areas are frequently disregarded by the users, fences are removed, and refuse is often dumped on the entrance roads to the landfills.

Cascade County is not satisfied with the present conditions at these sites and has decided to take over operations themselves. They are in the process of developing bulk container stations at or near four landfills that will be closed. The conversion to bulk container stations will overcome some of the existing operational difficulties such as blowing litter, indiscriminant dumping, and the need for daily cover; however, other operational problems* may be introduced, such as vandalism of the containers, freezing of the container contents in winter, inconvenience for weak or elderly persons unable to manage the heavy container lids, and dumping outside of the containers when solid waste generation is unusually heavy and the boxes are full.

The present cost of disposal in the Cascade County system is $3.15/tonne ($2.86/ton). On the basis of the same waste volumes, it is expected that these costs will increase after the county assumes operational responsibility because the labor and equipment required to meet the minimum state requirements (new landfill equipment, new containers, transport equipment for the containers, a landfill machine, and labor to perform landfill operation functions) is more extensive than that presently furnished by the contract. However, it is our opinion that the landfill operation will improve after the county assumes full control, if only because of additional labor and equipment and more frequent attention to the sites.

The landfill operation in Lake County, Florida is similar to that in Graham County, Arizona on a smaller scale. Although landfill equipment is permanently stationed at the larger sites, four of the landfills have a sharing system--i.e., two sites share one piece of equipment each. Occasionally equipment is shuttled between the other sites for a specific task such as digging trench when necessary.

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*The county reported no operating problems during the first six months of use.

The landfill operation staff in Lake County is about 18 times as large as the Graham County staff and the stable of equipment includes 8 pieces of landfill machinery, 1 tractor-trailer, 1 dump truck, and 8 pickup trucks--a total of 18 pieces as compared with Graham County's 2. All the Lake County sites are attended 10 hours a day, 6 days a week; an attendant is on duty to collect disposal fees as well as to ensure that unloading takes place only in designated areas. The presence of an attendant discourages indiscriminant dumping, scavenging, and vandalism.

The Lake County sites appear to be well kept. All refuse is compacted and covered at the end of each workday. A small problem was evident at one of the sites--debris was being dumped outside the fence on Sundays; strict enforcement of the litter laws may discourage the practice.

At the time of this study, Lake County was in the process of converting several of the smaller landfills in the sparsely populated areas of the county to transfer stations because the landfills were approaching capacity and other acceptable landfill sites were not readily available. Transfer stations seem to be a viable alternative for these outlying areas and are not expected to significantly increase disposal costs.

Lake County was one of only two study counties to maintain cost records. They have developed disposal costs as $1.65/tonne ($1.50/ton); however this cost does not include capital costs of the equipment or fringe benefits for employees. Our developed costs for the county including these costs are $2.44/tonne ($2.21/ton). We recommend that equipment owning costs be developed by Lake County so that a more accurate determination of disposal costs can be made. It is also recommended that all landfill and transfer station users be charged disposal fees, with a minimum charge for automobiles, to make this system more equitable and more self-supporting.

In Leon County, Florida the main landfill is operated by county equipment and the other six are operated by a contractor. The only equipment-sharing that is practiced is the use of a crawler tractor at five of these sites. Landfill equipment is permanently stationed at the two large-volume sites, which are maintained daily. The smaller sites receive periodic attention; although an effort is made to service these landfills each day, the daily deposits are often left uncovered for several days, and gulls have been a problem at these sites.

At the time of this study, Leon County was in the process of converting the five smaller and nearly completed landfills to bulk container transfer stations--an alternative that will better serve the residents of these rural areas of the county. Unloading areas consisting of a concrete

pad and retaining wall were already under construction and several of the small landfills were in the final stages of grading and revegetation as part of the closure operations. Leon County is negotiating for a new central sanitary landfill site of 183 hectares (452 acres) and is considering the initiation of user fees to be collected by a county attendant. The central landfill would be operated by county employees, and the bulk container stations would be operated by a contractor. Also under consideration is a plan for resource recovery, particularly paper, because of the large volumes generated by governmental agencies and educational institutions in the county.

The present disposal cost of $1.22/tonne ($1.11/ton) developed for this study is expected to increase in the future because the land for the new site is reported to cost $2,500.00/acre whereas all existing sites were free of charge.

Catron County, New Mexico practices bulk container transfer station disposal in conjunction with two sanitary landfill operations. No equipment-sharing is practiced in this system. Bulk containers are collected weekly for emptying and the landfills are open one day a week. With no attendants at these locations during the week, Catron County has had trouble with vandalism of the containers.

The transport equipment used in this operation is in need of refinement. The loading and unloading of the bulk containers onto the tractor-trailer hauling rig appears to be cumbersome and time-consuming. Transportation during the winter over narrow winding roads with no guard rails is sometimes hazardous.

Generally the disposal operation in Catron County serves the needs of the population. The county is the largest of the study sites and the least populated, with about 0.2 persons/km^2 (0.4 persons/$mile^2$). Because of the population served and the low volumes of solid waste generated the costs developed for disposal were the highest in this study--$8.99/tonne ($7.99/ton). However such a sparesely-settled area appears to be well suited for the container station disposal method.

SECTION 5

COST-ESTIMATING TOOL FOR RURAL LAND DISPOSAL OPERATIONS

Many potentially acceptable alternatives are available for the effective disposal of solid waste in rural areas. The case studies conducted for this report have identified three relatively inexpensive ones. The cost-estimating model presented below shows how the data collected can be used to design workable systems, and is intended for use by municipalities in the decision-making process. It must be understood that the data base for these options consists of costs developed from approximations and estimates.

HYPOTHETICAL MODEL

Assume a rural county currently operates three land disposal sites. Site A receives approximately 45 tons of solid waste per day (TPD), and Sites B and C receive 30 and 25 TPD, respectively. The amount of waste delivered has been estimated by assuming that each urban resident generates between 3.0 and 3.5 pounds per person per day, and each rural resident, 1.5 pounds per person per day. The commercial and industrial waste generation has been determined by personal contact with each source.

The county wishes to provide environmentally sound disposal but does not wish to establish a formal collection service. The disposal options being considered are as follows:

OPTION 1: Purchase one piece of landfill equipment and transport it from site to site each day using a tractor-trailer.

OPTION 2: Purchase one piece of landfill equipment and establish transfer stations at Sites B and C. Collect roll-off boxes from Sites B and C each day that Site A is open.

OPTION 3: Purchase three pieces of landfill equipment and station one piece of equipment at each site.

A cost estimate including capital costs, operating costs, and a projected cost per ton has been developed for each of these disposal options. The estimates are based on the following assumptions:

1. The land at each site is already owned by the county, therefore no cost of land is included.

2. Fencing, gates, and developments costs are $500 per acre for landfills and $2,000 per site for transfer stations.

3. Site A is a 10-acre site. Sites B and C are 6-acre sites.

4. All labor is estimated at $5.00 per hour, fringe benefits are estimated at 20 percent of total labor cost, and administrative (overhead) costs are estimated at 15 percent of total labor cost.

5. The round trip driving distance for all three sites is 50 miles. The distance from Site A to either Site B or C is 15 miles and from Site B to Site C is 20 miles.

6. Capital costs were derived in the following manner:

   For development costs, a 10-year life with interest at 8 percent was assumed.

   For transport and transfer equipment, a 5-year life with interest at 8 percent was assumed.

   For landfill equipment, hourly owning and operating costs from Table 18 were used; these costs were developed using an 8-hour day, a 5-day week, and 52 weeks per year.

7. In this example, costs per ton are based on a total of 26,000 tons per year (100 tons per day, 5 days per week).

Capital Costs

OPTION 1: Using assumptions 2 and 3, development and fencing costs are $11,000. Only one piece of landfill equipment is required for this option. From Table 18, a Model D-5 is chosen, at a total cost of $65,800. A tractor-trailer is needed to haul the landfill equipment; the cost for this equipment (developed from Table 15) is assumed to be $18,000. The total capital cost is $94,800 or $22,394.16/yr.

Development (3 landfills)	$11,000 @ 3% for 10 yrs	$ 1,602.48/yr
Owning Model D-5	$65,800 @ $7.89/hr	16,411.72/yr
Owning tractor-trailer	$18,000 @ 8% for 5 yrs	4,380.48/yr
TOTAL	$94,800	or $22,394.68/yr

$22,394.68 ÷ 26,000 tons = $0.86/ton

OPTION 2: Using assumptions 2 and 3, development and fencing costs are $5,000 for Site A and $2,000 each for Sites B and C. The landfill equipment requirements are the same as for Option 1 (Model D-5 from Table 18). Five roll-off boxes are required for transfer: two each for Sites B and C and one spare. The cost is assumed to be $1,500 per box. The truck to collect these boxes is assumed to cost $12,000. The total capital cost for this option is $94,300 or $22,467.84/yr.

Development (1 landfill, 2 transfer stations)	$ 9,000 @ 8% for 10 yrs	$ 1,311.12/yr
Owning Model D-5	$65,800 @ $7.89/hr	16,411.20/yr
Owning other equipment (5 roll-off boxes, 1 truck)	$19,500 @ 8% for 5 yrs	4,745.52/yr
TOTAL	$94,300	or $22,467.84/yr

$22,467.84 ÷ 26,000 tons = $0.86/ton

OPTION 3: Using assumptions 2 and 3, development and fencing costs are $11,000. Three pieces of landfill equipment are needed for the three sites. Three Model D-4s are chosen (from Table 18) at a cost of $45,300 each. The total capital cost for this option is $146,900 or $35,485.68/yr.

Development (3 landfills)	$ 11,000 @ 8% for 10 yrs	1,602.48/yr
Owning 3 Model D-4s	135,900 @ $5.43 ea/hr	33,883.20/yr
TOTAL	$146,900	or $35,485.68/yr

$35,485.68 ÷ 26,000 tons = $1.36/ton

Yearly Operating Costs

OPTION 1: One full-time operator is required for this option. It is assumed that the operator uses the landfill equipment 60 percent of the time and drives the tractor-trailer 40 percent of the time. The cost of operating the landfill equipment (Model D-5) is $7.48/hr (Table 18). The operating and maintenance cost for the tractor-trailer rig is assumed to be $1.50/mile loaded. Assuming one round trip per day to the three sites, five days per week, the operating and maintenance cost for the tractor-trailer rig is $19,500.

1 Operator	$5.00/hr x 2080 hrs	$10,400
fringes	20% of total labor	2,080
admin.	15% of total labor	1,560
Model D-5 (60% of the time)	$7.48/hr x 2080 hrs x 60%	9,335
Tractor-trailer	$1.50/mile x 13,000 miles/yr	19,500
	TOTAL	$42,875/yr

$42,875 ÷ 26,000 tons = $1.65/ton

OPTION 2: Two full-time operators are required for this system. It is assumed that the landfill equipment (Model D-5) operates full time. The tractor-trailer rig will be required to drive a total of 31,200 miles yearly--half of the hauling will be for loaded boxes, at a cost of $1.50/mile, and the other half for empty boxes, at a cost of $1.00/mile.

2 Operators x	$5.00 ea/hr x 2080 hrs	$20,800	
fringes	20% of total labor	4,160	
admin.	15% of total labor	3,120	
Model D-5 (full-time)	$7.48/hr x 2080 hrs	15,558	
Tractor-trailer	31,200 miles/yr		
hauling loaded boxes	15,600 miles @ $1.50/mile		$23,400
hauling empty boxes	15,600 miles @ $1.00/mile		15,600
	Hauling Subtotal		$39,000
	TOTAL	$82,638	

$82,638 ÷ 26,000 tons = $3.18/ton

OPTION 3: Three full-time operators are required for the three landfills in this system. The cost of operating the landfill equipment (three Model D-4s) is $5.22/hr. The landfill equipment operates full time.

3 Operators	x	$5.00 ea/hr x 2080 hrs	$31,200
fringes		20% of total labor	6,240
admin.		15% of total labor	4,680
3 Model D-4s	x	$5.22/hr x 2080 hrs	32,573
		TOTAL	$74,693

$74,693 ÷ 26,000 tons = $2.87/ton

Table 6 summarizes the cost estimates for all three systems and includes a projected cost per ton.

Because of the assumptions made in the development of this cost-estimating tool, the model is very specific and therefore not a general-purpose tool. No provisions have been included for a collection system; residents would be required to deliver their waste or contract to have their wastes delivered to the landfill or transfer station. Since residents are usually reluctant to support a decrease in service, these systems could not be used to replace an existing collection system. Also, with the residents hauling their own waste, greater volumes would probably be delivered to the sites on weekends. Therefore, the five-day work week should include Saturday. The optimum schedule of operations would have to be worked out by experimenting during the early stages of implementation. Options such as a five-day work week from Tuesday through Saturday, or paying five days' wages for a four-day week as an incentive to work on Saturdays might be considered.

Because very few operators are employed in any of the proposed options, the success of these operations depends largely on the individual operator. Irresponsibility or repeated or prolonged absence from the job by an operator could easily cause major problems in the disposal system. Another important requirement in the successful operation of these alternatives is that back-up landfill and transport equipment be available for use when the primary equipment is being repaired. Capital costs can be reduced by purchasing used equipment.

Table 6. SOLID WASTE DISPOSAL COST SUMMARY
(Based on 26,000 tons per year)

Item	OPTION 1 3 Landfills Equip. Sharing	OPTION 2 1 Landfill 2 Transfer	OPTION 3 3 Landfills No Sharing
CAPITAL COST			
Landfill Equipment	$65,800	$65,800	$135,900
Transport Equipment	18,000	--	--
Transfer Equipment	--	19,500	--
Development Costs	11,000	9,000	11,000
TOTAL	$94,800	$94,300	$146,900
YEARLY OPERATING COST			
Labor	$10,400	$20,800	$ 31,200
Fringes	2,080	4,160	6,240
Landfill Equipment	9,335	15,558	32,573
Transport Equipment	19,500	--	--
Transfer Equipment	--	39,000	--
Administration	1,560	3,120	4,680
TOTAL	$42,875	$82,638	$ 74,693
COST PER TON			
Capital Cost	$0.86	$0.86	$1.36
Operating Cost	1.65	3.18	2.87
TOTAL	$2.51	$4.04	$4.23

Municipalities using this cost-estimating tool will have to evaluate available options in terms of local conditions such as climate, terrain to be traveled, unemployment, and labor rates. Once a disposal system has been developed, modifications may have to be made through trial and error to optimize labor and equipment utilization.

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GLOSSARY*

BLADE.

Earth-A heavy, broad plate that is connected to the front of a tractor and is used to push and spread soil or other material.

Landfill-A U-blade with an extension on top that increases the volume of solid wastes that can be pushed and spread, and protects the operator from any debris thrown out of the solid waste.

U-Blade-A dozer blade with an extension on each side; they protrude forward at an obtuse angle to the blade and enable it to handle a larger volume of solid waste than a regular blade.

BUCKET. An open container affixed to the movable arms of a wheeled or tracked vehicle to spread solid waste and cover material, and to excavate soil.

BULLDOZER. A tracked vehicle equipped with an earth blade.

COLLECTION. The act of removing solid waste from the central storage point of a primary source.

Contract-The collection of solid waste carried out in accordance with a written agreement in which the rights and duties of the contractual parties are set forth.

Franchise-Collection made by a private firm that is given exclusive right to collect for a fee paid by customers in a specific territory or from specific types of customers.

Municipal-The collection of solid waste by public employees and equipment under the supervision and direction of a municipal department or official.

Private-The collection of solid waste by individuals or companies from residential, commercial, or industrial premises; the arrangements

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*Adapted from Solid Waste Management Glossary. U.S. Environmental Protection Agency. Washington, D.C. Publication Number SW-108ts. 1972. 20 p.

for the service are made directly between the owner or occupier of the premises and the collector.

COMPACTOR.

Sanitary Landfill-A vehicle equipped with a blade and with rubber tires sheathed in steel or hollow steel cores; both types of wheels are equipped with load concentrations to provide compaction and a crushing effect.

CONTAINER.

Lift and Carry-A large container that can be lifted onto a service vehicle and transported to a disposal site for emptying; also called a detachable container or drop-off box.

Roll-on/Roll-off-A large container [15 to 23 m^3 (20 to 40 yd^3)] that can be pulled onto a service vehicle mechanically and carried to a disposal site for emptying.

COVER MATERIAL. Soil that is used to cover compacted solid waste in a sanitary landfill.

CUT. Portion of a land surface or an area from which earth or rock has been or will be excavated. The distance between an original ground surface and an excavated surface.

DRAGLINE. A revolving shovel that carries a bucket attached only by cables and digs by pulling the bucket toward itself.

DUMP. A land site where solid waste is disposed of in a manner that does not protect the environment.

FRONT END LOADER. A collection vehicle with arms that engage a detachable container, move it up over the cab, empty it into the vehicle's body, and return it to the ground.

GRADER. A gas- or diesel-powered, pneumatic-wheeled machine equipped with a centrally located blade that can be angled to cast to either side.

GRADIENT. The degree of slope or a rate of change.

PUTRESCIBLE. Organic matter capable of being decomposed by microorganisms.

REFUSE. See SOLID WASTE.

RUBBISH. A general term for solid waste--excluding food waste and ashes--taken from residences, commercial establishments, and institutions.

SANITARY LANDFILLING. An engineered method of disposing of solid waste on land in a manner that protects the environment, by spreading the waste in thin layers, compacting it to the smallest practical volume, and covering it with soil by the end of each working day.

SANITARY LANDFILLING METHOD.

Area-A method in which the wastes are spread and compacted on the surface of the ground and cover material is spread and compacted over them.

Trench-A method in which the waste is spread and compacted in a trench. The excavated spoil is spread and compacted over the waste to form the basic cell structure.

SCAVENGER. One who participates in the uncontrolled removal of materials at any point in the solid waste stream.

SEWAGE SLUDGE. A semiliquid substance consisting of settled sewage solids combined with varying amounts of water and dissolved materials.

SLASH. Logging and land-clearing debris.

SLUDGE. A semiliquid sediment.

SOLID WASTE. Useless, unwanted, or discarded material with insufficient liquid content to be free flowing.

Agricultural-The solid waste that results from the rearing and slaughtering of animals and the processing of animal products and orchard and field crops.

Commercial-Solid waste generated by stores, offices and other activities that do not actually turn out a product.

Demolition-Building materials and rubble resulting from construction, remodeling, repair, and demolition operations.

Industrial-Solid waste that results from industrial processes and manufacturing.

Institutional-Solid wastes originating from education, health care, and research facilities.

Municipal-Normally, residential and commercial solid waste generated within a community.

Residential-All solid waste that normally originates in a residential environment. Sometimes called domestic solid waste.

TRANSFER STATION. A site at which solid waste is concentrated and then taken to a processing facility or sanitary landfill.

TRANSPORT. The movement of solid waste subsequent to collection.

TRASH. See RUBBISH.

VECTOR.

Disease Vector-A carrier, usually an arthropod, that is capable of transmitting a pathogen from one organism to another.

APPENDIX A

SANITARY LANDFILL OPERATION DATA

APPENDIX A
Sanitary Landfill Operation Data

Table 7. SANITARY LANDFILL OPERATION DATA COLLECTED FROM GRAHAM COUNTY, ARIZONA

Landfill site	Distance between the sites, km (miles)[a]	Highway travel time	Daily volumes of refuse reported, m^3 (yd^3)	Hrs/day open to public	Days/wk open to public	Operator's time utilization			
						Site cleanup	Site preparation[b]	Operation	Visits to the site
Artesia[b]	Artesia to San Jose 24 (15)	40 min.	11-1/2 - 15 (15 - 20)	24	7	1-1/2 - 2 hrs.	4 hrs.	30 min. spread/compact 30 min. cover	daily
San Jose	San Jose to Central 25 (16)	30 min.	6 - 9 (8 - 12)	24	7	1 - 2 hrs.	4 hrs.	1 hr. spread/ compact 30 min. cover	daily
Central	Central to Eden 21 (13)	25 min.	24-1/2 - 27 (32 - 35)	24	7	2 - 3 hrs.	4 - 5 hrs.	2 hrs. spread/ compact 30-40 min. cover	daily
Eden	Central to Ft. Thomas 24 (15)	30 min.	3 - 5-1/2 (4 - 7)	24	7	1/2 hr.	4 hrs.	30-45 min.	weekly
Ft. Thomas			2-1/2 - 4 (3 - 5)	24	7	1/2 hr.	4 hrs.	30-45 min.	weekly

[a]Distances are given on the basis of the operator's travel route with landfill equipment. Operator starts each day at the county maintenance yard in Safford and returns at the end of the day.

[b]Trench is excavated when needed; life of trench varies from one week to several months depending on site.

Table 8. SANITARY LANDFILL OPERATION DATA
COLLECTED FROM HABERSHAM COUNTY, GEORGIA

Landfill site	Distance between sites, km (miles)[a]	Highway travel time between sites[a]	Weekly volumes of refuse reported m^3 (yd^3)	Hrs/day open to public	Days/wk open to public	Operator's time utilization		
						Site cleanup	Site preparation	Operation
Cornelia	13 (18)	20-30 min.	1,140 (1,490)	10	6	2-3 hrs.	3-4 hrs.	4-5 hrs. spread/ compact 1-2 hrs. cover
Clarkesville			550 (720)	10	6	1-3 hrs.	2-4 hrs.	2-5 hrs. spread/ compact 1-2 hrs. cover

[a]Operator travels with landfill equipment between the two sites.

Table 9. SANITARY LANDFILL OPERATION DATA COLLECTED FROM CASCADE COUNTY, MONTANA

Landfill site	Daily volumes of refuse reported, tonnes (tons)	Hrs/day open to public	Days/wk open to public	Operator's time utilization		
				Site cleanup, minutes	Site preparation, minutes	Operation, minutes
Vaughn[a]	11 (12)	24	7	30	30	30
Ft. Shaw[b]	6 (6.8)	24	7	30	30	30
Ulm[b]	6-1/2 (7)	24	7	45	30	45-60
Sand Coulee[b]	8 (8-1/2)	24	7	30	30	30
Stockett[b]	7-1/2 (8.3)	24	7	30	30	30
Monarch[b]	2 (2.3)	24	7	30	30	30

[a]Vaughn is the only site operated by the county.

[b]These sites are under contract ($25,000/yr) for routine landfill operations which include spreading, compacting, and covering. Trench excavation is performed on a time and materials basis when needed. Equipment is hauled to the sites from the contractor's yard and various other locations in the county; a strict schedule for making these trips is not maintained by the contractor.

Table 10. SANITARY LANDFILL OPERATION DATA
COLLECTED FROM LAKE COUNTY, FLORIDA

Landfill site	Monthly volumes of refuse reported, m^3 (yd^3)	Hrs/day open to public	Days/wk open to public	Operator's time utilization		
				Site cleanup, hrs.[a]	Site preparation, hrs.	Operation, hrs.
Astatula	10,660 (13,940)	10	6	6-8	8	8
Umatilla[b]	3,820 (5,000)	10	6	2-3	4	4
Astor	1,640 (2,150)	10	6	2-3	4	4
Paisley[b]	2,060 (2,700)	10	6	2-3	4	4
Lady Lake	4,370 (5,720)	10	6	2-3	4	4
Stuckey[c]	2,190 (2,860)	10	6	2-3	4	4
Log House[c]	3,380 (4,420)	10	6	2-3	4	4

[a]Site cleanup is performed by attendant.

[b]Landfill equipment is moved once a day between Umatilla and Paisley--a distance of 21 km (13 miles).

[c]Landfill equipment is moved once a day between Stuckey and Log House--a distance of 26 km (16 miles).

Table 11. SANITARY LANDFILL OPERATION DATA
COLLECTED FROM LEON COUNTY, FLORIDA

Landfill site	Monthly volumes of refuse reported	Hrs/day open to public	Days/wk open to public	Operator's time utilization		
				Site cleanup, hrs.[b]	Site preparation, hrs.	Operation, hrs.
Spring Hill[a]	8,240 m^3 (10,780 yd^3)	9	6	6-8	8	9
Lakewood[c]	2,680 m^3 (3,500 yd^3)	9	6	2-3	4	3-4
Woodville[c]	1,910 m^3 (2,500 yd^3)	9	6	2-3	4	3-4
Miccosukee[c]	770 m^3 (1,000 yd^3)	9	6	1-2	4	2-3
Tram Road[c]	1,680 m^3 (2,200 yd^3)	9	6	2-3	4	3-4
Ft. Braden[c]	1,760 m^3 (2,300 yd^3)	9	6	2-3	4	3-4
Trash Dump[d]	9,900 tonnes (11,000) tons	9	6	9	9	9

[a]Spring Hill is the main landfill.

[b]Cleanup is performed by an attendant.

[c]Active landfill is to be closed.

[d]Trash Dump is reserved for demolition, etc. and is operated by contract.

Table 12. SANITARY LANDFILL OPERATION DATA
COLLECTED FROM CATRON COUNTY, NEW MEXICO

Site	Distance between sites km (miles)	Highway travel time, minutes	Daily volumes of refuse reported, m^3 (yd^3)	Hrs/day open to public	Days/wk open to public	Operator's time utilization		
						Site cleanup	Site preparation[a]	Operation
Glenwood Landfill	--	--	15 (20)	9	1 (Saturday)[b]	30 min.	10 days to dig trench	1-2 hrs.
Alma Container Station	Glenwood to Alma 11 (7)[c]	20	Unknown	24	7	15 min.	45 min.	--
Mogollone Container Station	Glenwood to Mogollone 21 (13)[c]	35	Unknown	24	7	15 min.	45 min.	--
Reserve Landfill	Glenwood to Reserve 63 (39)	50	19 (25)	9	1 (Saturday)[b]	1 hr.	10-12 days to dig trench	3-4 hrs.
Cruzville Container Station	Reserve to Cruzville 16 (10)[d]	25	Unknown	24	7	15 min.	45 min.	--
Aragon Container Station	Reserve to Aragon 31 (19)[d]	40	Unknown	24	7	15 min.	45 min.	--
Luna Container Station	Reserve to Luna 29 (18)[d]	40	Unknown	24	7	15 min.	45 min.	--
Rancho Grande Container Station	Reserve to Rancho Grande 26 (16)[d]	40	Unknown	24	7	15 min.	45 min.	--

[a]Site preparation at the container stations is for unloading empty container and loading full container on the transporter.

[b]Container is stationed outside of fence for everyday use.

[c]Trips are made to transport bulk containers to Glenwood for emptying.

[d]Trips are made to transport bulk containers to Reserve for emptying.

APPENDIX B

SANITARY LANDFILL COST DATA

APPENDIX B
Sanitary Landfill Cost Data

Table 13. YEARLY SALARIES FOR EMPLOYEE CLASSIFICATIONS IN 1975[a]

County	Director/ Supervisor	Superintendent/ Admin. Assistant	Mechanic	Equipment Operator	Attendant/ Laborer	Remarks
Graham	$12,000			$8,910		Equipment operator also serves as landfill operator.
Habersham		$ 9,100			1 @ $5,200 2 @ $4,160	Superintendent also serves as equipment operator.
Cascade	$11,388		$8,808	$8,808	$8,448	Director devotes 50% of his time to solid waste disposal.
Lake	$15,000	$12,000 Adm. Asst. $ 9,000 Supervisor	$7,500	$7,200 (Type I) $7,000 (Type II) (7 each)	$4,888 $3.52/hr. over-time. (Avg. 10 hrs. o.t./wk. (8 each)	Director and Administrative Assistant not on full-time solid waste disposal.
Leon	$18,000	$ 9,880 plus overtime		$8,590 plus overtime (3 each)	$5,075 plus overtime (2 each)	Director oversees other environmental departments in addition to solid waste.
Catron				$5,016 $2,616		Equipment operators also serve as landfill operator.

[a]Most of the employees in these classifications at the study sites devote portions of their time to duties other than solid waste disposal. Therefore the labor costs calculated for the landfill operators (see Table 18) reflect appropriate percentages of these salaries.

Table 14. LANDFILL EQUIPMENT DATA

County	Make	Model	Size-Capacity	Purchase Condition	Cost	Age or Yr. purchased	Remaining life	Remarks
Graham	Caterpillar	D-5 Bulldozer	12 tonne (13-1/2 ton) 105 HP	New	$45,000.00	1972	6-8 yrs.	
Habersham	Caterpillar	D-7 Bulldozer	21 tonne (23 ton) 200 HP	New	$75,338.48	Feb. 1975	8 yrs. Min.	For use at both sites.
	Caterpillar	D-6 Bulldozer	14-1/2 tonne (16 ton) 144 HP	New	Unknown	29 yrs.	5-8 yrs.	On loan from Hwy. Dept.
	International	E-200 Self-Propelled Wheel Scraper	11-1/2m^3 (15-yd^3)	New	Unknown	10 yrs.	4-6 yrs.	On loan from Hwy. Dept.
	Caterpillar	D-7 Tractor with 5-1/2-m^3 (7-yd^3) Wheel Scraper	19 tonne (21 ton) 200 HP 5-1/2-m^3 (7-yd^3) Pan	New	Unknown	27 +/- yrs.	5-8 yrs.	On loan from Hwy. Dept.
	Caterpillar	D-7 Tractor Bulldozer	21 tonne (23 ton) 200 HP	New	Unknown	20 + yrs.	5-8 yrs.	On loan from Hwy. Dept.
Cascade	Case	1000-D Front End Loader-Track	1-m^3 (1-1/2-yd^3) G.P. Bucket	Used	$ 8,000.00	7 yrs.	2-3 mos.	In sad shape. Replaced in December 1975.
	Caterpillar	955-L	2-m^3 (2-1/4-yd^3) G.P.Bucket	New	$62,900.00	Oct. 7, 1975	8 yrs.	Equipment not in use at time of investigation.
	Contractor Equipment	Crawler Tractor	1-m^3 (1-1/2 yd^3)	Unknown	Unknown	6 yrs. (estimate)	3-4 yrs.	Owned and operated by Contractor.

Table 14 (continued). LANDFILL EQUIPMENT DATA

County	Make	Model	Size-Capacity	Purchase Condition	Cost	Age or Yr. purchased	Remaining life	Remarks
Lake	Koehring	Dragline Crawler No. 405	1-m^3 (1-1/4 yd^3)	New	$ 50,000.00	1970	8-12 yrs.	
	International	TD-25-C Bulldozer	32 tonne (35 ton)	New	$101,000.00	1971	6-8 yrs.	
	Northwest	Crawler Dragline No. 255	1/2-m^3 (3/4 yd^3)		$ 35,000.00 (when new)	12 yrs.	3-4 yrs.	Obtained from Mosquito Control Department.
	International	TD-15 Bulldozer	125 HP 14-1/2 tonne (16 ton)	New	$ 55,300.00	Transferred at 7 yrs. of age	3-4 yrs.	Obtained from Roads and Bridges Department.
	International	TD-15 Bulldozer	125 HP 14-1/2 tonne (16 ton)	New	$ 55,300.00	1973	6-8 yrs.	
	International	TD-15 Bulldozer	125 HP 14-1/2 tonne (16 ton)	New	$ 55,300.00	1973	6-8 yrs.	
	International	175B Loader	2-m^3 (2-1/4-yd^3) G.P. Bucket	New	$ 39,900.00	1968	4-6 yrs.	
	Caterpillar	933 Traxca-vator	1-1/2-m^3 (2 yd^3) 8 tonne (9 ton)	New	$ 16,700.00	1968	6-8 yrs.	
Leon	Rex	Trash Master Compactor	54-1/2 tonne (60 ton)	New	$ 80,000.00	Dec. 1970	2-3 yrs.	At Spring Hill landfill.
	Caterpillar	D-8 Bulldozer	32 tonne (35 ton) 300 HP	New	$ 84,000.00	Dec. 1970	8 yrs.	At Spring Hill landfill.

Table 14 (continued). LANDFILL EQUIPMENT DATA

County	Make	Model	Size-Capacity	Purchase Condition	Cost	Age or Yr. purchased	Remaining life	Remarks
Leon	Link Belt	Model 98 Dragline	1-m^3 (1-1/2-yd^3) Bucket	New	$ 42,000.00	Dec. 1970	8-10 yrs.	At Spring Hill landfill.
	Allis-Chalmers	HD-21	28 tonne (31 ton) 270 HP	Used 11 years old	Unknown	Dec. 1970	8-10 yrs.	Obtained from Hwy. Dept.
	Caterpillar	D-7	20 tonne (22 ton) 180 HP	New	Unknown	32 yrs.	Unknown	Obtained from Hwy. Dept.
Catron	Massey Ferguson	MF 3366 Bulldozer	60 HP 10-1/2 tonne (11-1/2 ton)	New	$ 16,900.00	Sept. 1973	2 yrs.	Reserve landfill model discontinued in 1974.
	Massey Ferguson	MF 3366 Bulldozer	60 HP 10-1/2 tonne (11-1/2 ton)	New	$ 16,570.00	June 1974	5 + yrs.	Glenwood landfill model discontinued in 1974.

Table 15. TRANSPORT EQUIPMENT DATA

County	Make	Model	Size-Capacity	Purchase Condition	Cost	Year purchased	Remaining life	Remarks
Graham	GMC	Unknown	11 tonne (12-1/2 ton)	New	$ 8,000.00	1974	6-8 Yrs.	
	Trailer	Low Bed	18 tonne (20 ton)	New	$ 7,500.00	1974	10 Yrs.	
Habersham	GMC	Unknown	32 tonne (35 ton)	Used 4 Yrs. old	$ 7,500.00	1975	5 Yrs.	
	Low Boy Trailer	Unknown	Combination	Used 4 Yrs. old	$ 7,500.00	1975	10 Yrs.	
Cascade	International	Unknown	2 tonne (2-1/2 ton)	New	$ 7,840.00	1974	10 Yrs.	Replaced in early 1976.
	Trailer	Tilt Bed	23 tonne (25 ton)	New	$ 9,000.00	1974	15 Yrs.	
Lake	GMC	Unknown	400 HP Gas Engine	New	Unknown	1958	1-2 Yrs.	Obtained from Roads and Bridges Department.
	Trailer	Low Boy	23 tonne (25 ton)	New	Unknown	1958	1-2 Yrs.	Obtained from Roads and Bridges Department.
	Various Ford Chevrolet	Unknown	0.4 tonne (1/2 ton) Pickup Trucks	New	Unknown	Between 1958 and 1975	2-4 Yrs.	For use by equipment and landfill operators.
Leon[a]								
Catron	Ford	F 250	0.7 tonne (3/4 ton)	New	$ 4,450.00	1975	5 Yrs.	Reserve site.
	Chevrolet	Unknown	0.7 tonne (3/4 ton)	New	Unavailable (Assume $4,200.00)	New 1970 Transferred 1973	4 Yrs.	Acquired from Highway Department in 1973 for Glenwood.
	Trailers (3 each)	Local Manufacture	9 tonne 10 ton)	New	$11,925.00	July 1973	5 Yrs.	Trailers for hauling bins.
	Bins (containers) 9 each	Local Manufacture	6 @ 12 m^3 (16 yd^3) 3 @ 15 m^3 (20 yd^3)	New	$11,550.00 Total	1973	3-5 Yrs.	

[a]No transport equipment assigned to Solid Waste Department. When needed, it is requisitioned from Highway Department.

Table 16. 1975 LANDFILL EQUIPMENT COSTS --MASSEY FERGUSON[a]

Cost Item	Model 200 44 HP 3/4 yd^3 MP Bucket	Model 300 63 HP 1-1/4 yd^3 MP Bucket	Model 400 85 HP 1-5/8 yd^3 MP Bucket	Model 500 185 HP 2 yd^3 MP Bucket	Model 600 200 HP 2-1/2 yd^3 MP Bucket
Delivered price[b]	$18,000.00	$28,500.00	$36,500.00	$43,500.00	$50,000.00
HOURLY COSTS OF OWNING					
Depreciation[c]	$ 1.44	$ 2.28	$ 2.92	$ 3.48	$ 4.00
Interest,[d] insurance, taxes	$ 0.29	$ 0.85	$ 1.08	$ 1.29	$ 1.40
Total hourly owning cost	$ 1.73	$ 3.13	$ 4.00	$ 4.77	$ 5.40
HOURLY COSTS OF OPERATING					
Fuel[e]	$ 0.32	$ 0.44	$ 0.60	$ 0.92	$ 1.20
Grease, lube oils, hydr. oils	$ 0.74	$ 0.98	$ 1.22	$ 1.46	$ 1.70
Filters and disposable supplies[f]	$ 0.26	$ 0.36	$ 0.45	$ 0.54	$ 0.60
Repairs	$ 1.62	$ 2.57	$ 3.29	$ 3.92	$ 4.50
Total hourly operating costs	$ 2.94	$ 4.35	$ 5.56	$ 6.84	$ 8.02
TOTAL HOURLY OWNING AND OPERATING COSTS	$ 4.67	$ 7.48	$ 9.56	$ 11.61	$ 13.50

[a]From Massey-Ferguson brochures.

[b]Price includes OSHA requirements plus multi-purpose bucket, heating, and air-conditioning.

[c]Estimated life with proper maintenance (according to equipment manual) is 10,000 hrs. (about 5 yrs.) For salvage or trade-in value use 20 percent of initial cost.

[d]Interest computed at 7 percent annually.

[e]Diesel fuel assumed cost is $0.11/liter ($0.40/gal.); lubricating oils cost is $0.53/liter ($2.00/gal.); grease cost is $1.10/kg ($0.50/lb.)

[f]Routine maintenance every 150 hrs.

Table 17. 1975 LANDFILL EQUIPMENT COSTS--FIAT-ALLIS[a]

Cost Item	Fiat-Allis Model 12-G 3 yd^3 MP Bucket	Fiat-Allis Model FL 14-B 2-1/4 yd^3 MP Bucket	Fiat-Allis Model FL 10-B 1-7/8 yd^3 MP Bucket	Fiat-Allis Model FL-9 1-5/8 yd^3 MP Bucket
Delivered price[b]	$80,000.00	$60,000.00	$45,000.00	$35,000.00
HOURLY COSTS OF OWNING				
Depreciation[c]	$ 6.40	$ 4.80	$ 3.60	$ 2.80
Interest,[d] insurance, taxes	$ 2.40	$ 1.80	$ 1.35	$ 1.05
Total hourly owning cost	$ 8.80	$ 6.60	$ 4.95	$ 3.85
HOURLY COSTS OF OPERATING				
Fuel[e]	$ 2.72	$ 1.60	$ 1.36	$ 1.12
Grease, lube oils, hydr. oils	$ 0.84	$ 0.82	$ 0.79	$ 0.74
Filters and disposable supplies[f]	$ 0.33	$ 0.29	$ 0.27	$ 0.26
Repairs	$ 7.20	$ 5.40	$ 4.05	$ 3.15
Total hourly operating costs	$ 11.09	$ 8.11	$ 6.47	$ 5.27
TOTAL HOURLY OWNING AND OPERATING COSTS	$ 19.89	$ 14.71	$ 11.42	$ 9.12

[a]From Fiat-Allis brochures.

[b]Price includes OSHA requirements plus multi-purpose bucket, heating, and air-conditioning.

[c]Estimated life with proper maintenance (according to equipment manual) is 10,000 hrs. (about 5 yrs.)
For salvage or trade-in value use 20 percent of initial cost.

[d]Interest computed at 7 percent annually.

[e]Diesel fuel assumed cost is $0.11/liter ($0.40/gal.); lubricating oils cost is $0.53/liter ($2.00/gal.); grease cost is $1.10/kg ($0.50/lb.)

[f]Routine maintenance every 150 hrs.

Table 18. 1975 LANDFILL EQUIPMENT COSTS--CATERPILLAR TRACTOR CO.[a]

Cost Item	Model 941	Model D-4	Model D-5	Model D-6	Model D-7	Model D-8	Model 977 MP	Model 955	Model 951
Delivered price[b]	$42,200.00	$45,300.00	$65,800.00	$80,000.00	$110,600.00	$147,000.00	$95,700.00	$61,600.00	$49,800.00
HOURLY COSTS OF OWNING									
Depreciation[c]	$ 2.37	$ 3.62	$ 5.26	$ 6.40	$ 8.85	$ 11.70	$ 7.65	$ 4.93	$ 3.98
Interest,[d] insurance, taxes	$ 1.69	$ 1.81	$ 2.63	$ 3.20	$ 4.42	$ 5.88	$ 3.83	$ 2.46	$ 1.99
Total hourly owning cost	$ 5.06	$ 5.43	$ 7.89	$ 9.60	$ 13.27	$ 17.58	$ 11.48	$ 7.39	$ 5.97
HOURLY COSTS OF OPERATING									
Fuel[e]	$ 1.36	$ 1.04	$ 1.40	$ 1.88	$ 3.00	$ 4.16	$ 2.96	$ 2.28	$ 1.68
Grease, lube oils, hydr. oils Filters and disposable supplies[f]	$ 0.21	$ 0.11	$ 0.16	$ 0.21	$ 0.26	$ 0.30	$ 0.27	$ 0.24	$ 0.22
Repairs	$ 3.80	$ 4.07	$ 5.92	$ 7.20	$ 9.95	$ 13.23	$ 8.61	$ 5.54	$ 4.48
Total hourly operating costs.	$ 5.37	$ 5.22	$ 7.48	$ 9.29	$ 13.21	$ 17.69	$ 11.84	$ 8.06	$ 6.38
TOTAL HOURLY OWNING AND OPERATING COSTS	$ 10.43	$ 10.65	$ 15.37	$ 18.89	$ 26.48	$ 35.27	$ 23.32	$ 15.45	$ 12.35

[a]From Caterpillar Tractor Co. brochures.

[b]Price includes OSHA requirements plus multi-purpose bucket, heating, and air-conditioning.

[c]Estimated life with proper maintenance (according to equipment manual) is 10,000 hrs. (about 5 yrs.) For salvage or trade-in value use 20 percent of initial cost.

[d]Interest computed at 7 percent annually.

[e]Diesel fuel assumed cost is $0.11/liter ($0.40/gal.); lubricating oils cost is $0.5:./liter ($2.00/gal.); grease cost is $1.10/kg ($0.50/lb.).

[f]Routine maintenance every 150 hrs.

Table 19. YEARLY DISPOSAL COSTS FOR THE STUDY COUNTIES DEVELOPED ON THE BASIS OF COLLECTED DATA AND OBSERVATIONS

County	Total volumes, in tonnes/yr. (tons/yr.)	Labor Costs	Assigned overhead costs[a]	Equipment owning and operating costs	Contract costs	Total costs per year	Cost per tonne (ton)[b]
Graham	5,300 (5,900)	$ 10,110.	$ 2,125.	$ 21,050.	$------	$ 33,285.	$ 6.30 ($ 5.66)
Habersham	26,500 (29,100)	$ 22,620.	$ 4,750.	$ 28,890.	$------	$ 56,260.	$ 2.12 ($ 1.93)
Cascade	14,965 (16,500)	$ 10,385.	$ 2,180.	$ 2,050.	$32,510.	$ 47,125.	$ 3.15 ($ 2.86)
Lake	114,848 (126,620)	$126,030.	$26,470.	$127,335.	$------	$279,835.	$ 2.44 ($ 2.21)
Leon	210,100 (231,400)	$ 47,600.	$10,000.	$155,925.	$42,000.	$255,525.	$ 1.22 ($1.11)
Catron	3,200 (3,600)	$ 12,820.	$ 2,690.	$ 13,260.	$------	$ 28,770.	$ 8.99 ($ 7.99)

[a]Assigned overhead costs are assumed as 21 percent of payroll.

[b]As delivered.

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